

**GENERAL DYNAMICS**

FORT WORTH DIVISION

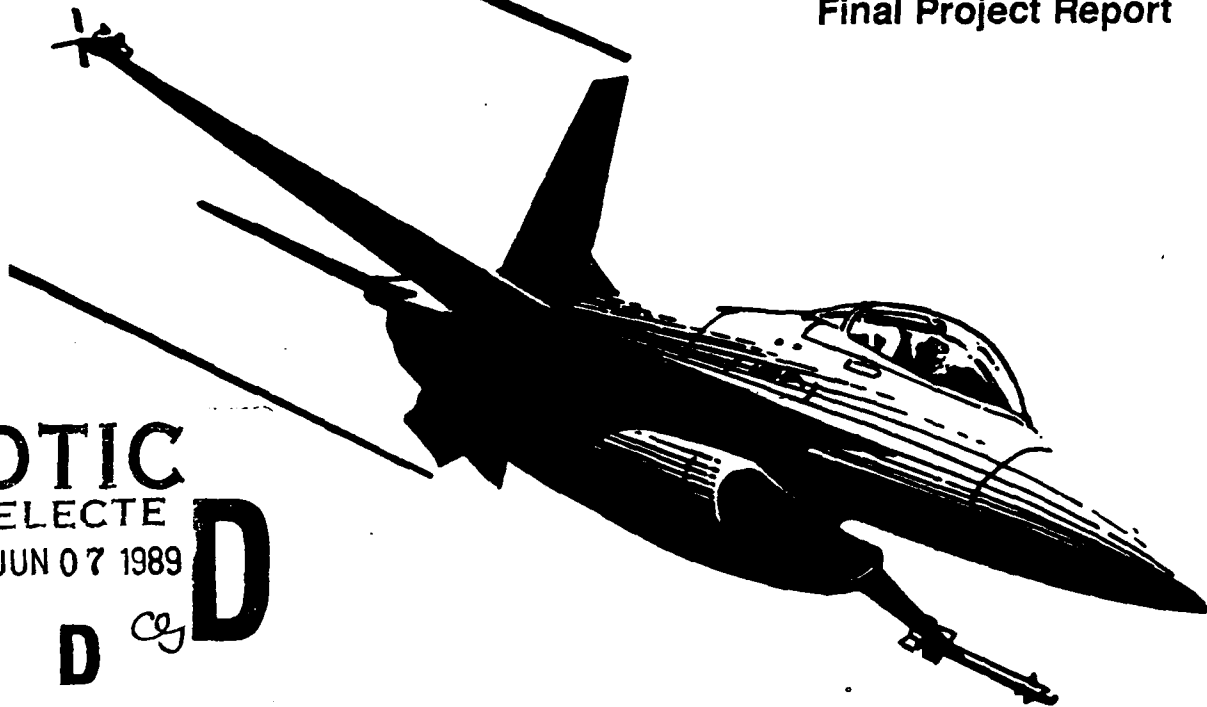
# **INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM**

Phase 2

Final Project Report

AD-A209 164

DTIC  
ELECTE  
JUN 07 1989  
S D *cg* D



PROJECT 88

IMPROVE MATERIAL HANDLING,  
COMPUTERIZED STORAGE/RETRIEVAL  
SYSTEM (CS/RS)

REVISION 1

DISTRIBUTION STATEMENT A

Approved for public release  
Distribution Unlimited

**Honeywell**

Military Avionics Division

89 2 13 141

# REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION unclassified		1b. RESTRICTIVE MARKINGS None	
2a. SECURITY CLASSIFICATION AUTHORITY Honeywell		3. DISTRIBUTION / AVAILABILITY OF REPORT Unlimited	
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE None			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) None Cited		5. MONITORING ORGANIZATION REPORT NUMBER(S) 448307BB H089-0302	
6a. NAME OF PERFORMING ORGANIZATION Honeywell, MAVD	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION General Dynamics/Ft. Worth	
6c. ADDRESS (City, State, and ZIP Code) St. Louis Park, MN 55416		7b. ADDRESS (City, State, and ZIP Code) Fort Worth, TX 76101	
8a. NAME OF FUNDING / SPONSORING ORGANIZATION F-16 SPO	8b. OFFICE SYMBOL (If applicable) ASD	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract# F33657-82-C-2034 P.O.# 1005262	
8c. ADDRESS (City, State, and ZIP Code) Dayton, OH 45433		10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. PROJECT NO. TASK NO. WORK UNIT ACCESSION NO.	
11. TITLE (Include Security Classification) Phase 2 Final Project Report #88 - Improve Material Handling, Computerized Storage/ Retrieval System (CS/RS) Revision 1			
12. PERSONAL AUTHOR(S) Robert Knox			
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM 1986 TO 1988	14. DATE OF REPORT (Year, Month, Day) 88, 04, 01	15. PAGE COUNT 147
16. SUPPLEMENTARY NOTATION CDRL ITM-004			
17. COSATI CODES FIELD GROUP SUB-GROUP 13 08		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Transformer manufacture, electronic chassis manufacture, VS/RS, ergonomic work stations.	
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This project addresses the modernization of the factory layout of the electronic chassis, transformer, and epoxy production areas. This is to be accomplished through more efficient use of floor space, utilization of automated storage and retrieval systems, streamlining work flow, and installation of ergonomically designed work cell/work centers. Incorporation of these changes will result in increased productivity and yields from a reduction in rework training, and throughput time.			
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Captain Curtis Britt		22b. TELEPHONE (Include Area Code) 513-258-4263	22c. OFFICE SYMBOL YPTM

# **Honeywell**

**APRIL 1, 1988**

**GENERAL DYNAMICS  
FORT WORTH DIVISION**

**INDUSTRIAL TECHNOLOGY  
MODERNIZATION PROGRAM**

**PHASE 2 FINAL PROJECT REPORT**

**PROJECT 88**

**IMPROVE MATERIAL HANDLING,  
COMPUTERIZED STORAGE/RETRIEVAL  
SYSTEM (CS/RS)**

**REVISION 1**

**AVIONICS SYSTEMS GROUP  
MILITARY AVIONICS DIVISION  
1625 ZARTHAN AVE  
ST. LOUIS PARK, MN 55416**

# PROJECT 88

## TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1	INTRODUCTION	1
2	PROJECT PURPOSE/OVERVIEW	3
3	TECHNICAL APPROACH	6
4	"AS-IS" PROCESS	39
5	"TO-BE" PROCESS	74
6	PROJECT ASSUMPTIONS	87
7	GROUP TECHNOLOGY CODING SYSTEM ANALYSIS	88
8	PRELIMINARY/FINAL DESIGN AND FINDINGS	90
9	SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS	117
10	TOOLING	122
11	VENDOR/INDUSTRY ANALYSIS/FINDINGS	123
12	EQUIPMENT/MACHINERY ALTERNATIVES	126
13	MIS REQUIREMENTS/IMPROVEMENTS	127
14	COST BENEFIT ANALYSIS AND PROCEDURE	129
15	IMPLEMENTATION PLAN	136
16	PROBLEMS ENCOUNTERED AND HOW RESOLVED	139
17	AREA FOR FUTURE CONCERNS/DEVELOPMENT	141



Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

## PROJECT 88

### LIST OF ILLUSTRATIONS

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
3.1-1	PROJECT APPROACH AND METHODOLOGY	7
3.1-2	TYPICAL ITERATIVE PROCESS	9
3.1.1-1	MULTI-DIMENSIONAL SPACE EXAMPLE	11
3.1.2-1	OVERVIEW OF METHODOLOGY	13
3.1.2-2	DEVELOPMENT OF CHASSIS AREA LAYOUT	15
3.2.1-1	WORK CENTER	17
3.2.1-2	WORKSTATION/PROCESS	20
3.2.4-1	VALUATION OF CRITERIA	27
3.3-1	METHODOLOGY FLOW DIAGRAM	28
3.3-2	WORK AREA DESIGN METHODOLOGY	30
3.3-3	WORK AREA (CELL/STATION) ORGANIZATION	33
3.4-1	EQUIPMENT SELECTION APPROACH	34
3.4-2	TOOLING AND EQUIPMENT EVALUATION MATRIX	37
4.0-1	"AS-IS" PRODUCTION PROCESS (FM&TS)	40
4.3-1	FM&TS WORK CENTER STRUCTURES	43
4.4.2-1	CHASSIS GROUP LEADER ACTIVITIES SUMMARY	47
4.4.2-2	TRANSFORMER GROUP LEADER ACTIVITIES SUMMARY	48
4.5-1	CHASSIS & TRANSFORMER AREAS "AS-IS" LOCATION	50
4.5.1-1	"AS-IS" CHASSIS AREA	52
4.5.2-1	TRANSFORMER PRODUCTION AREAS (AS-IS FLOOR PLAN)	53
4.6.1-1	"GENERIC" CHASSIS ASSEMBLY AS-IS PROCESS FLOW	54
4.6.1-2	CURRENT PRE-WIRE WRAP TO WIRE WRAP CHASSIS PRODUCTION FLOW	56

## LIST OF ILLUSTRATIONS (CONTINUED)

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
4.6.1-3	CURRENT WIRE WRAP TO POST-WIRE WRAP CHASSIS PRODUCTION FLOW	57
4.6.1-4	CURRENT POST-WIRE WRAP TO DITMCO CHASSIS PRODUCTION FLOW	58
4.6.2-1	"GENERIC" TRANSFORMER ASSEMBLY AS-IS PROCESS FLOW	60
4.6.2-2	TYPICAL TRANSFORMER PRODUCTION FLOW	61
4.7-1	CHASSIS ASSEMBLY AND DITMCO AS-IS MATERIAL FLOW	63
4.7-2	TRANSFORMER ASSEMBLY AND TEST AS-IS MATERIAL FLOW	64
4.8.1-1	GAPOS SYSTEM BLOCK DIAGRAM	66
4.8.1-2	COMPUTERIZED SCHEDULE GENERATION	68
5.1-1	"TO-BE" PRODUCTION PROCESS (FM&TS)	75
5.2-1	CHASSIS & TRANSFORMER AREAS TO-BE LOCATIONS	77
5.2.1-1	"TO-BE" CHASSIS AREA LAYOUT	78
5.2.2-1	"TO-BE" TRANSFORMER AREA LAYOUT	80
8.2.1-1	CHASSIS AREA OPERATIONS GROUPING	93
8.2.1-2	TYPICAL CHASSIS PRODUCTION FLOW	96
8.2.1-3	FUTURE FM&TS - INITIAL AREA LAYOUT	97
8.2.1-4	INITIAL CHASSIS AREA DESIGN	99
8.2.1-5	"TO-BE" CHASSIS AREA LAYOUT	100
8.2.2-1	TYPICAL TRANSFORMER PRODUCTION FLOW	104
8.2.2-2	"TO-BE" TRANSFORMER AREA LAYOUT	105
8.4.1.1-1	CHASSIS AREA STORAGE VOLUMES	110
8.4.1.1-2	STORAGE MANAGEMENT SYSTEM ELEMENTARY SOFTWARE DIAGRAM	111

### LIST OF ILLUSTRATIONS (CONTINUED)

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
9.1-1	STORAGE MANAGEMENT SYSTEM ELEMENTARY SOFTWARE DIAGRAM	119
14.0-1	COST BENEFIT ANALYSIS METHODOLOGY	130
14.3-1	PROJECT 88 EXPENDITURE SCHEDULE	134
14.4-1	PROJECT 88 CASH FLOWS	135
15.1-1	PROJECT 88 - IMPLEMENTATION PLAN	137

## **PROJECT 88**

### **IMPROVE MATERIAL HANDLING, COMPUTERIZED STORAGE/RETRIEVAL SYSTEM (CS/RS)**

#### **SECTION 1**

#### **INTRODUCTION**

The Flight Management and Targeting Systems (FM & TS) Production Department is chartered to manage and produce a variety of fixed and rotary wing aircraft electronics in support of the Flight Systems Operation (FSO).

The mission of FM & TS Production is to generate revenue and profit by executing production contracts in support of FSO profit and ROI objectives. FM & TS products are typically low volume, high technology devices built under specific customer contracts. The FM & TS Area produces flight control and helmet mounted sighting/display systems for fixed and rotary-wing military aircraft for various customers. Project 88 is concerned with the area layout and material handling in the Transformer and Chassis assembly areas which are parts of FM & TS.

The Transformer Area may be thought of as a factory within a factory and functions basically as a service group which produces a variety of high-quality precision magnetics for FM & TS as well as other groups within Honeywell. The assemblies are built to tight requirements meeting individual device needs. The group also builds engineering models for development programs. As a result, the Transformer Area produces a large variety of transformers making flexibility within the group a high priority.

The primary function of the Chassis Area is the production of chassis assemblies for the devices produced by FM & TS. Some work for other groups within Honeywell is also performed but is relatively limited in scope. The chassis assemblies, which are unique to each type of device, generally consist of a base plate, side and bottom panels, a front panel with I/O connectors and indicators of various sorts, and a heat sink panel on which high power dissipation components are mounted. Most of the device interconnections among the base plate and I/O connectors is done using semi-automatic wire wrap machines. The remainder of the interconnections are accomplished using hand solder techniques. The chassis also require various amounts of mechanical assembly such as riveting, staking, and screw/nut assembly.

Project 88 was initiated to provide increased efficiency by the use of material handling and production flow improvements in the chassis and transformer areas within FM & TS. These improvements include:



- Chassis Area
  - Consolidation of storage for fixturing and tooling
  - Consolidation of material storage
  - Floor plan layout emphasizing straight-line flow
  - "Cluster" arrangement of workstations
  - Integration of work areas into more efficient groupings
  - Reduction of material search time by production personnel
- Transformer Area
  - Consolidation of storage for all process material
  - Floor plan layout emphasizing minimum flow distances
  - Productivity enhancements through utilization of modular workstations
  - Consolidation of "scattered" work areas
  - Reduction of material search time by production personnel

These improvements implemented under Project 88 will provide FM & TS with a significant increase in the efficiency of their manufacturing and help to reduce their overall manufacturing costs.

## **SECTION 2**

### **PROJECT PURPOSE/OVERVIEW**

The following section presents an overview of ITM Project 88. An overview of the FM & TS Production department and its primary objectives is also presented along with a brief description of the Tech Mod efforts at Honeywell.

#### **2.1 FM & TS Overview**

Flight Management and Targeting Systems (FM & TS) Production is chartered to manage and produce a variety of fixed and rotary wing aircraft electronics in support of the Flight Systems Operation (FSO).

The mission of FM & TS Production is to generate revenue and profit by executing production contracts in support of FSO profit and ROI objectives. FM & TS products are typically low volume, high technology devices built under specific customer contracts. The FM & TS Production organization directly provides Production Engineering, Production Control, and operating capabilities to manage and execute production programs, support engineering programs, and provide specialized services to other product areas. Quality, Logistics, Procurement and Manufacturing Technical Services support is provided to FM & TS Production by Honeywell's Military Avionics Division (MAvD) central organizations.

The priority objective within FM & TS Production is to produce quality products within cost goals. Additional objectives include flexibility and dependability with the emphasis differing slightly in each of the focused factories.

#### **2.2 FM & TS and Tech Mod**

The USAF Tech Mod program was instituted to provide strategic planning and develop facility modernization projects that reduce manufacturing costs, improve product quality and reliability, and reduce manufacturing throughput time. In addition, the Tech Mod program has been chartered with assuring the capability for a rapid increase in production in the event of national emergency.

Under the guidance of the Tech Mod program, Honeywell has defined several areas for improving production in the Flight Management and Targeting Production facility in St. Louis Park, Minnesota. ITM Project 88 for upgrading FM & TS Chassis and Transformer Area Production has been defined and is described in the following section.

## 2.3 Project 88 Strategic Goals and Objectives

FM & TS Production has defined several major objectives that are being incorporated in their future business planning. These objectives include increasing the flexibility of their operations and improving product quality, while maintaining a high degree of cost control.

Cost control is the overriding objective of FM & TS Production planning. This control must be maintained for both existing program production as well as for new programs. The cost control efforts underway in FM & TS Production are wide-ranging and are being applied at every level of the organization. Examples of this can be seen in the current implementation of the HMS/BOS MRP II system in St. Louis Park as well as the implementation of the Factory Data Collection System. In addition to controlling costs, the following objectives have been defined as critical to FM & TS's future production operations:

- **Increase flexibility of operations.** FM & TS will manufacture between six and ten products at any particular time and with the introduction of new programs which introduce both process and product changes, the current operations must remain flexible in adapting to these changes while still maintaining the capability of supporting existing programs.
- **Increase product quality.** By achieving 100% conformance with customer requirements, Honeywell will be viewed as the leading supplier of Military Avionics products. While this is of important strategic value from a marketing perspective, it can also have a direct effect on lowering the manufacturing costs in such areas as reducing rework and scrap.
- **Reducing production lead times.** Customer requirements dictate shorter production lead times and these will be accomplished through developing more streamlined process, material, and production flows. Improvements in information processing (such as HMS and FDC) will also aid in reducing production lead times.

ITM Project 88 has been defined by the Honeywell Tech Mod Project Team for implementation in Flight Management and Targeting Systems Production. This project, as defined by the Tech Mod Project Team, is described below.

ITM Project 88 addresses the modernization of the factory layout of the chassis, transformer, and epoxy areas within the FM & TS department. This modernization is to be accomplished through more efficient use of floor space, utilization of vertical storage and retrieval systems (VS/RS), consolidation of

transformer assembly operations, streamlining work flow, and installation of ergonomically designed work cell/work centers. The benefits associated with the implementation of ITM Project 88 include:

- Increased productivity in transformer area winding, leadset, and epoxy operations
- Clustering of higher volume activities
- Reduced dependency on material movement by support personnel
- Reduced Group Leader effort in material search and transport
- Reduced production control effort in material search and transport
- Centralized, high efficiency material storage
- Significant reduction in work flow distances
- More efficient flow of work within operational areas
- Built in potential for upgrade to fully integrated material tracking system

This project represents a significant part of the overall Tech Mod program currently being administered in Honeywell's Military Avionics Division.

## **SECTION 3**

### **TECHNICAL APPROACH**

The following subsections describe the general approach and methodology adopted by the Project 88 team for this project.

The first subsection describes the overall approach and methodology for performing an in-depth analysis of the FM & TS chassis and transformer area's operations and presents the methods employed in developing a structured design for more advanced operations and material handling methods. In addition, this section presents the evaluation methods used to establish technical requirements which define the possible material handling improvements within the Chassis and Transformer operations.

The second subsection introduces the philosophy of developing a manufacturing operations structure by first defining hierarchical levels employed in a manufacturing environment and the characteristics of production with respect to the impact of decisions concerning product versus process orientation (or a mix of these) at each of these levels. The ITM Project 88 objectives are then described as they relate to each of the hierarchical levels defined and the variables and criteria necessary for making recommendations for each of these levels is presented. These criteria are utilized more extensively in Sections 4 and 5 in defining and developing the advanced design of the transformer and chassis areas.

Subsection three presents the factors that affect the design of work areas (both work cells and workstations). The methodology of developing requirements for optimally designed work cells and workstations is presented along with the development of specific material handling requirements. Ergonomic design philosophies are described as they were employed in the development of the specific work stations as well as the overall area layouts and material handling designs.

The final subsection describes the approach developed for selecting material handling equipment. This includes the methodology used to develop requirements for equipment, the selection criteria, and the high level evaluation matrices.

#### **3.1 Overview of Project Approach and Methodology**

The project team has developed an overall approach for performing ITM Project 88 which is summarized in Figure 3.1-1. During the initial phase of the project, this approach required the collection of a great deal of information, including:

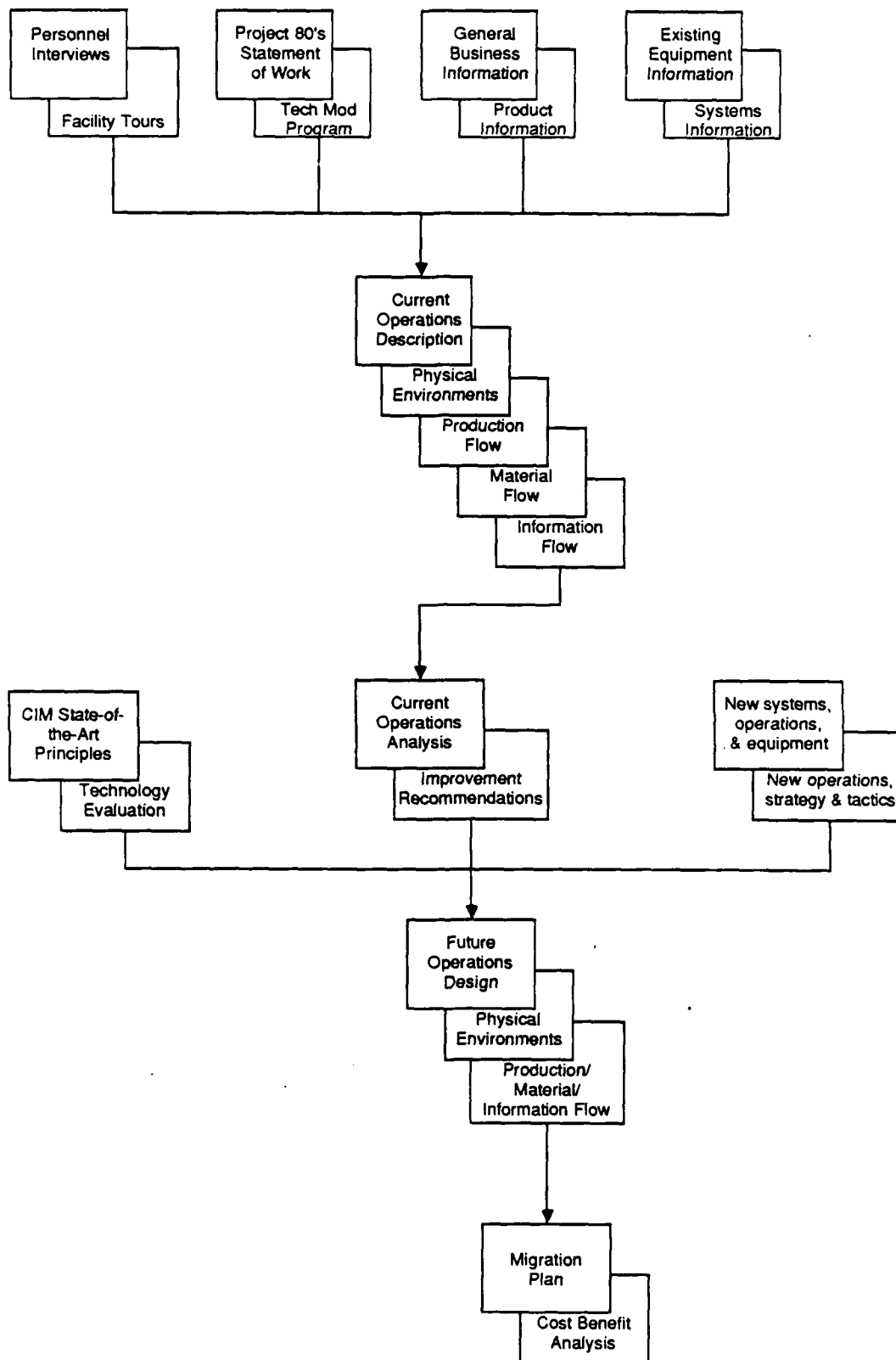


Figure 3.1-1 Project Approach and Methodology

- Project 88 Statement of Work
- Tech Mod Program Goals
- FM & TS Business
- FM & TS Products
- Personnel Interviews
- Facility Tours
- Chassis and Transformers Area Existing Material Handling Methods and Equipment
- Chassis and Transformers Area Existing Systems

This information was assimilated by the project team and presented in a series of meetings designed to assure that the project team fully understood the various facets of the FM & TS Chassis and Transformer current operations. The analysis resulting from this exercise, along with the technological understanding of similar operations to that of FM & TS, were then utilized in developing the future material handling operations design as well as the relayout of the area to provide a more streamlined production flow, material flow, and information flow.

The final phase in this process is the development of an implementation plan which outlines the implementation steps required to achieve the final plan and a cost benefit analysis which defines the benefits in respect to the necessary investment and the time required to realize a return on Honeywell's investment.

In utilizing the approach described above, the project team has found that an iterative process methodology would yield the best results in the creative process of designing systems and operations similar to the FM & TS operations. This methodology is particularly applicable in the type of environment, both from a physical perspective as well as a business and management perspective, that exists for the Honeywell project team.

In the early stages of the project, the iterative process consisted of the presentation of information collected and assimilated by the project team in a concise format. After an agreement as to the adequacy of the presentation was reached at this level, the process moved further into more detailed levels. This is the basis of the iterative process. Further iterations addressed the first initial conceptual levels of design and, as more detail was agreed upon, more precise elements of the design were put into place.

The feedback generated as a result of each of these presentations and the incorporation of this information into the final report assures that the results of the overall design process are compatible with the desires and ideas expressed by the user's and management organization. The iterative design process is illustrated in a conceptual manner in Figure 3.1-2.

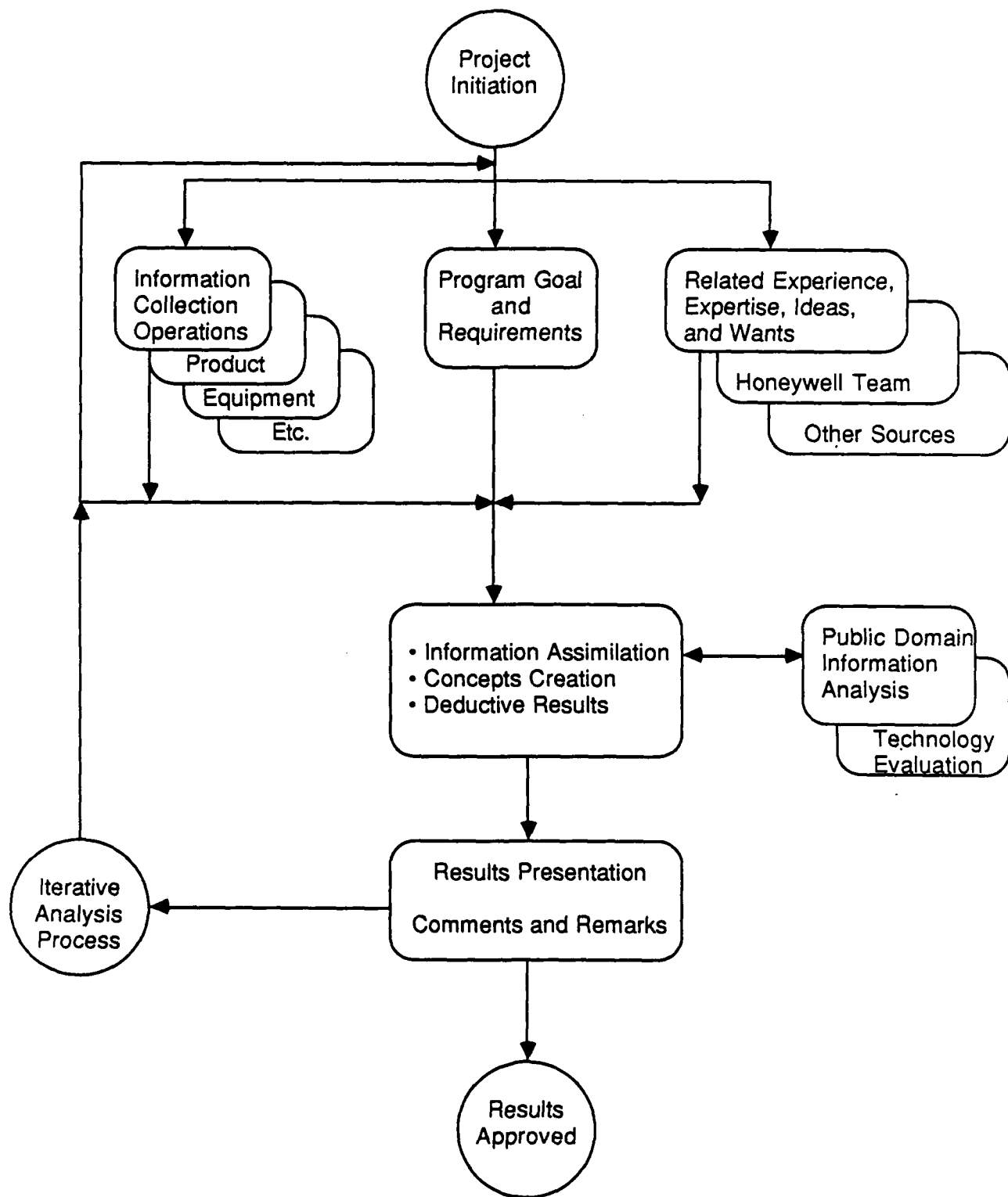


Figure 3.1-2 Typical Iterative Process



### 3.1.1 Operations Analysis

The goal of a comprehensive operations analysis is to first describe the current operations of Honeywell's FM & TS Chassis and Transformer areas. Based upon this description, specific areas and operations are defined (in accordance with the statement of work) for further analysis as they significantly impact the direct or indirect costs of FM & TS production. This analysis then provides the foundation upon which the operations of the future is designed.

The absolute and definitive areas which are identified as cost drivers in the Transformer and Chassis operations lie in a multi-dimensional space with complex interrelated dimensions that are difficult to delineate. The primary task in the analysis phase is to determine the methods and approach required to define and analyze an issue which is extremely complex. As shown in Figure 3.1.1-1, this multi-dimensional space is characterized by the hierarchical levels existing within the FM & TS organization and the specific objectives of ITM Project 88.

By specifying the general objectives to be achieved, it is possible to reduce the complexity of these interrelated dimensions and to define objectives for each of the levels of operations and analyze improvements to be made at each level. Once these objectives have been defined at a specific level, it is then necessary to establish the significant variables and criteria that will influence the analysis and recommendations made for each of these levels.

While the variables and criteria are defined more comprehensively in Section 3.2.3, they are briefly summarized as:

- Production
  - Physical Arrangement
  - Process Flow
  - Group Technology
- Material
  - Material Management
  - Material Handling
- Information
  - Systems
  - Control Networks

In addition, several criteria have also been developed. These include such considerations as cost (capital investment, ROI, etc.) as well as product profiles and several other areas.

Once the project objectives have been finalized, the hierarchical levels defined, and the criteria and variables established, it is then possible to define the correlations between all of these dimensions and begin the structured



design process as described in the following section and utilized throughout the progress of this report.

### **3.1.2 Structured Design Approach**

The structured design approach employed by the project team is directly dependent upon a detailed analysis of the specific FM & TS operations for the transformer and chassis areas. The previous section described the methodology used to approach a large, complex, interrelated structure and "break down" that structure into discrete entities (i.e., work cells and workstations). Once the operations have been analyzed at a discrete enough level to understand the processes and unique characteristics at each level, it is possible to rebuild each of the levels progressively to transform the operations into a more advanced manufacturing structure.

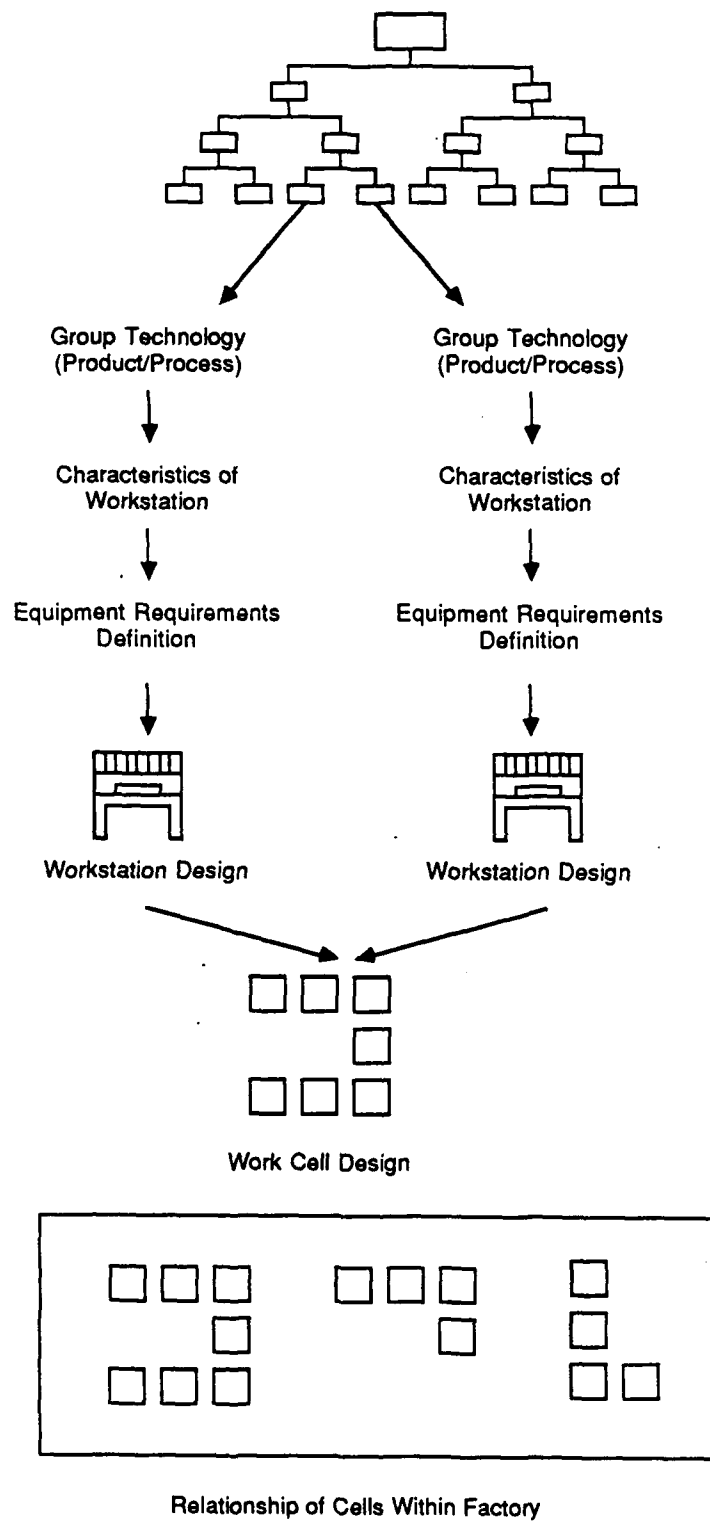
A general overview of this "rebuilding" process is presented in Figure 3.1.2-1. Once the analysis phase has been developed to the workstation and process level, it is then beneficial to analyze each product and discrete process in respect to Group Technology. The term Group Technology has been alternately used to describe

- 1) a process of codifying parts in a computer database in order to group similar parts or
- 2) the organization of product families into cells in order to eliminate the duplication of resources.

A codifying of all parts used at Honeywell would be an extremely large undertaking and would require the coordination of several divisions to assure its effectiveness and to realize significant cost savings. While this would be an worthwhile endeavor for Honeywell, this was not a reasonable task for the implementation of ITM Project 88. However, the project team developed matrices to define the specific miscellaneous hardware used in the chassis and transformer areas as an aid in establishing proposed equipment and workstation requirements.

In addition, large scale matrices were developed which correlated the Honeywell part number (of each assembly, sub-assembly, and component part of all products produced by FM & TS) with the operations and the standard hours required to perform these operations. These correlation matrices provided important information for grouping similar processes at workstations, defining the equipment required at each specific type of workstation as well as the actual number of workstations required for each of these groupings of operations.

In accordance with ITM Project 88, a number of other factors, which are primarily concerned with the overall area layout and the material handling requirements for these areas, have influenced the general workstation design



**Figure 3.1.2-1 Overview of Methodology**

requirements. The relationship of these factors to the overall design process is shown in Figure 3.1.2-2. The primary additional factors which also affect the design definition include:

- Production Volumes
- Material Movement and Transport Means
- Workstation Storage Requirements
- Work Area Storage Requirements

Once the design of new workstations, processes, and additional requirements for testing and other areas are defined, it is necessary to present specific technical solutions that can be implemented in the most efficient and effective manner.

### **3.2 Manufacturing Operations Structure**

The manufacturing operations in Honeywell's FM & TS Production area have been structured both to reflect an overall Honeywell approach to divisional responsibility and in response to the changing product and production requirements. In order to develop the optimum manufacturing solutions for FM & TS production, it is necessary to "break down" the manufacturing operations structure into more discrete entities or levels that can be analyzed separately before "restructuring" the operations to provide a global alternative to their current operations.

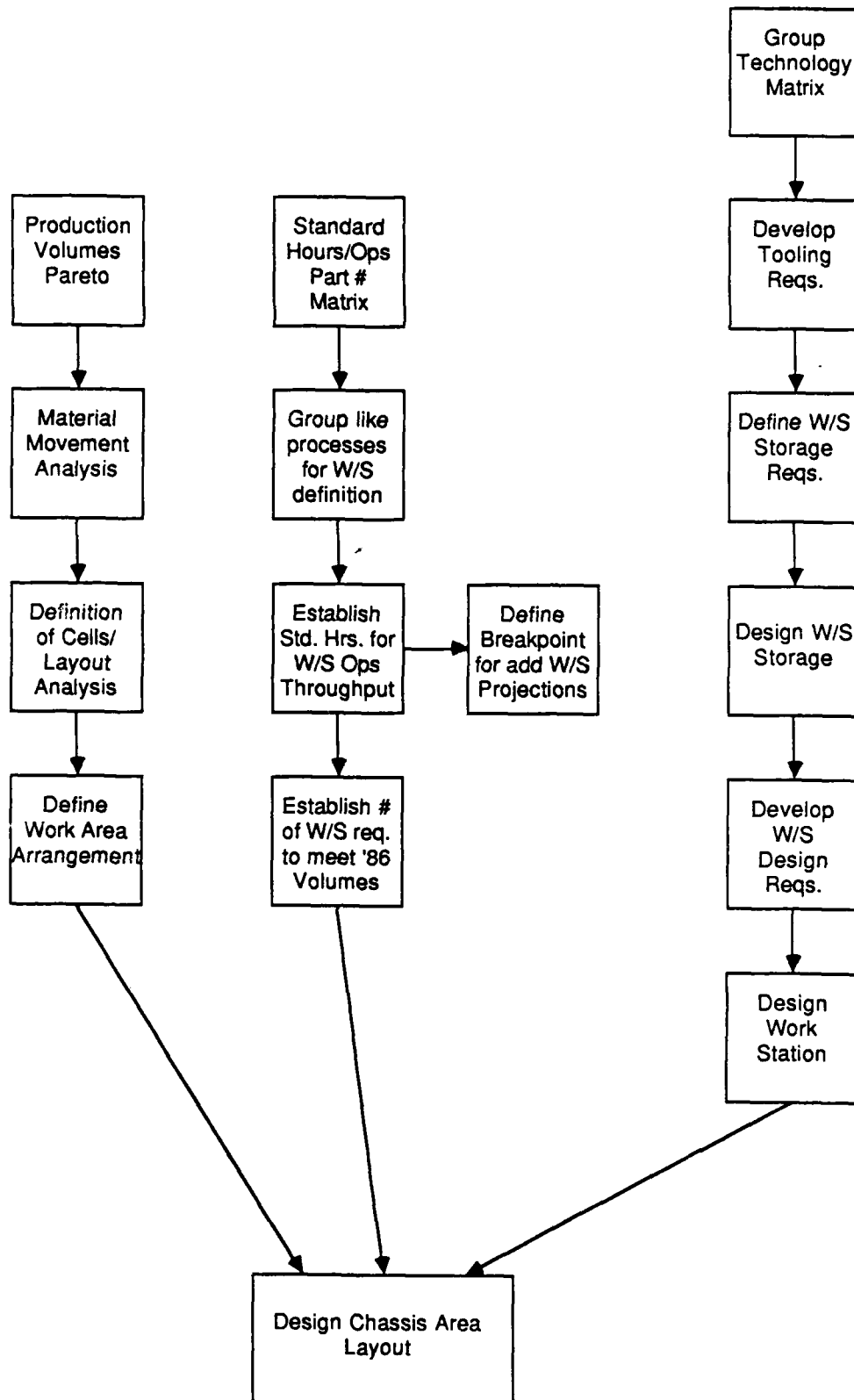
Once these levels have been defined, a trade-off analysis can be made regarding production principles at each of these levels and for the effect the characteristics of these principles have at each of the levels and the sub-groups within these levels. The primary production principles described in this section can be defined in terms of either product orientation or process orientation.

The analysis of operations structure is applied to the specific objectives of ITM Project 88. This provides an assessment of the impact of these principles at each level addressed by the project and defines the project objectives with respect to each level.

Following the detailed definition of the project's objectives, the specific variables that influence decision making at each of the levels and the criteria that must be met to accomplish the project objectives are determined. The variables can be defined as global considerations for developing cost drivers for the overall project. The criteria then provide the specific elements which must be evaluated for specific ROI and payback analysis that will determine the justifiability of each of the improvements recommended.

#### **3.2.1 Definition of Hierarchical Manufacturing Levels**

The current trends in analyzing manufacturing operations structures is to view the manufacturing structure in a hierarchical manner. This approach



**Figure 3.1.2-2 Development of Chassis Area Layout**

provides the basis for determining the ways in which manufacturing is performed as well as the influence of the structure on the actual manufacturing operations.

The primary divisions that are typically defined are:

- Company
- Division
- Factory
- Work Center
- Work Cell
- Workstation/Process

Each of the hierarchical levels below the Division level is described in detail in the following paragraphs. While some of these descriptions may imply computer controlled actions at each level, these actions are actually possible either through a computer control system or through a manual "paper-based" system. Subsequent sections (Sections 4 and 5) define each of the hierarchical levels as they apply to the current FM & TS operations and the proposed FM & TS manufacturing operations respectively.

### **Factory**

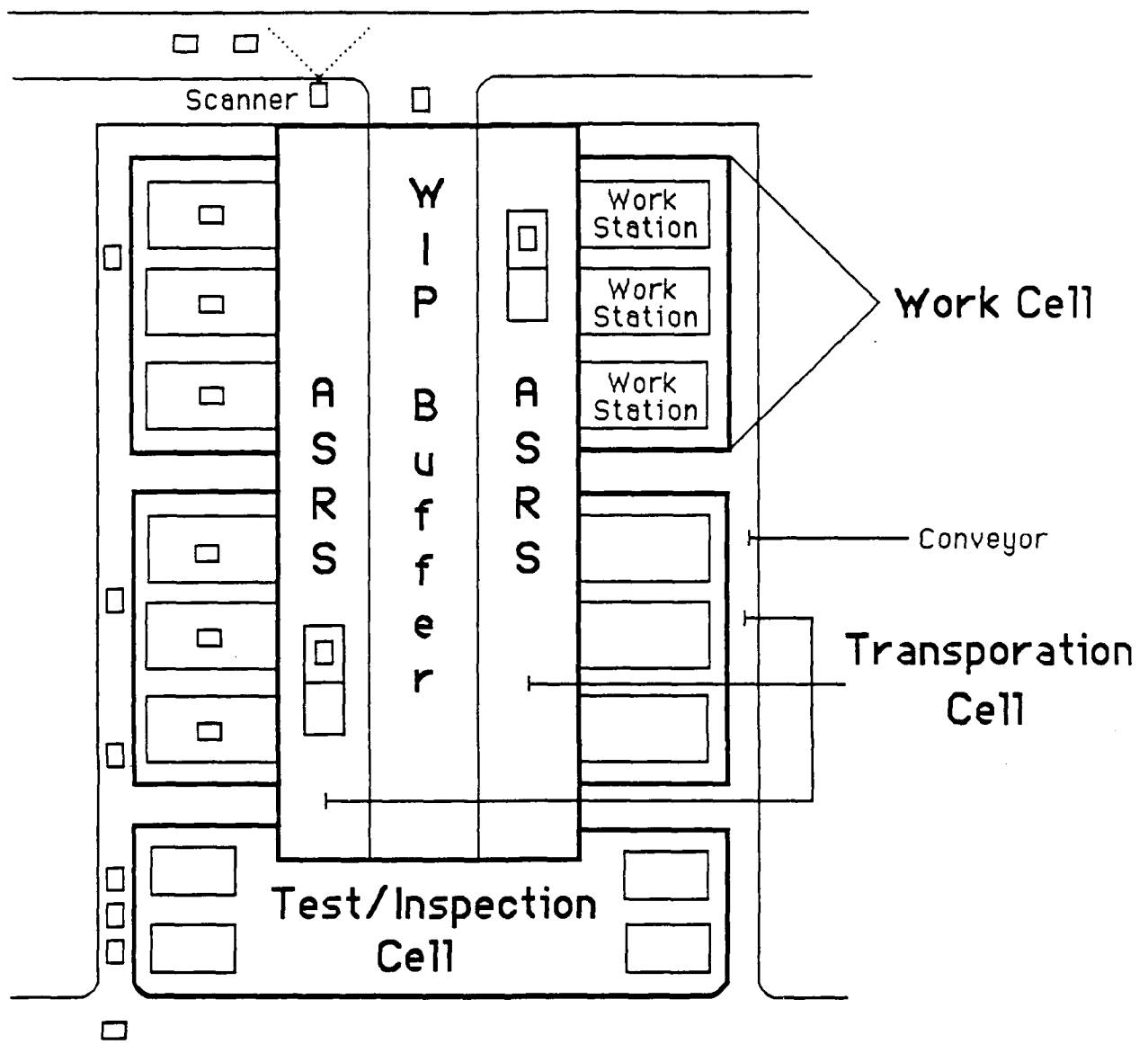
The factory level (also known as the plant level) is responsible for all production operations for a related set of products. In response to divisional or corporate forecasts, the factory develops a manufacturing resource plan to achieve these goals. In addition, the factory is responsible for monitoring the overall efficiency and productivity of the manufacturing resources.

Included within the factory are the shipping and receiving functions, warehousing, administration and manufacturing services, data processing, and the entities which are responsible for the production processes.

From a systems perspective, the factory level is where MRP (Material Requirements Planning) or MRP II (Manufacturing Resources Planning) systems reside. These types of systems take a macro view of the production operations as an integral part of the entire operation of the factory. Production and the processes entailed are viewed from this level as financial entities and therefore, the most important information required at this level is the rate of production, inventory levels, production completions, and other financial related data.

### **Work Center**

The work center level (which is shown conceptually in Figure 3.2.1-1) is responsible for the production of a specific product line or a set of related sub-assemblies or products. In a general view, the work center is responsible for



Responsible for production of a specific product line or set of related subassemblies

Optimizes near-term resource schedules to meet factory production plans (specific resource allocations)

Authorizes actual manufacture of products associated with the work center

Monitors performance and near-term availability of work center resources.

**Figure 3.2.1-1 Work Center**



coordinating the actual manufacture of a product involving all of the required processes and procedures.

To meet production objectives, the work center is responsible for a greater range of tracking production than a units/time period level. The work center allocates specific resources and provides near-term scheduling to meet the overall factory production plans. In performing this, it is responsible for authorizing the actual manufacture of products, the release of materials to the manufacturing floor, as well as the transference of product from manufacturing to shipping.

The work center is also responsible for monitoring the performance and near-term availability of work center resources. These resources include inventory levels and replenishment, material transfer and transportation means, processes, in-process storage, and several others.

### **Work Cell**

The work cell (whether physical or logical) is responsible for performing a specific set of related operations or factory services. This can be defined as a specific sub-assembly or a specific process required by all sub-assemblies or assemblies. The work cell is also responsible for coordinating all activities among the workstations within the cell. This includes authorization of workstation activation and deactivation, tool changes, intra-cell material handling, and other inter-station activities.

The work cell also monitors at a discrete level each of the workstations within the cell as far as exact location and current process being performed. With this data, the work cell can then direct corrective action with respect to exception conditions at workstations or can notify the local operator as to a required action.

### **Workstation**

Workstations are responsible for controlling the execution of one or more linked processes. The workstation initiates commands for specific actions to the appropriate process. In addition, the workstation monitors process activities through command acknowledgements and exception alerts.

### **Process**

Processes are specific steps executed within an operation. At this low level, process controls provide acknowledgement of each command received and report each relevant action taken. As with workstations, the process control level reports exception conditions with respect to specific machine operations.

A conceptual overview of the workstation and process responsibilities is shown in Figure 3.2.1-2.

### **3.2.2 Production Characteristics**

Production characteristics describe the type of production operations that are employed for a particular set of products and are dependent upon a variety of factors including build schedule, lot sizes, product characteristics, and many other factors. The primary division of production characteristics is between functionally oriented (or process oriented) manufacturing and product oriented manufacturing. Additionally, characteristics of production may define the need for a mix between a functional and product orientation.

The assignment of production characteristics need not be global for an organization but should be determined when applied to each of the hierarchical levels within the factory. The following paragraphs briefly summarize the major distinctions between process and product manufacturing orientations and what the determining factors are in applying these characteristics at each manufacturing level.

#### **Product Oriented Manufacturing**

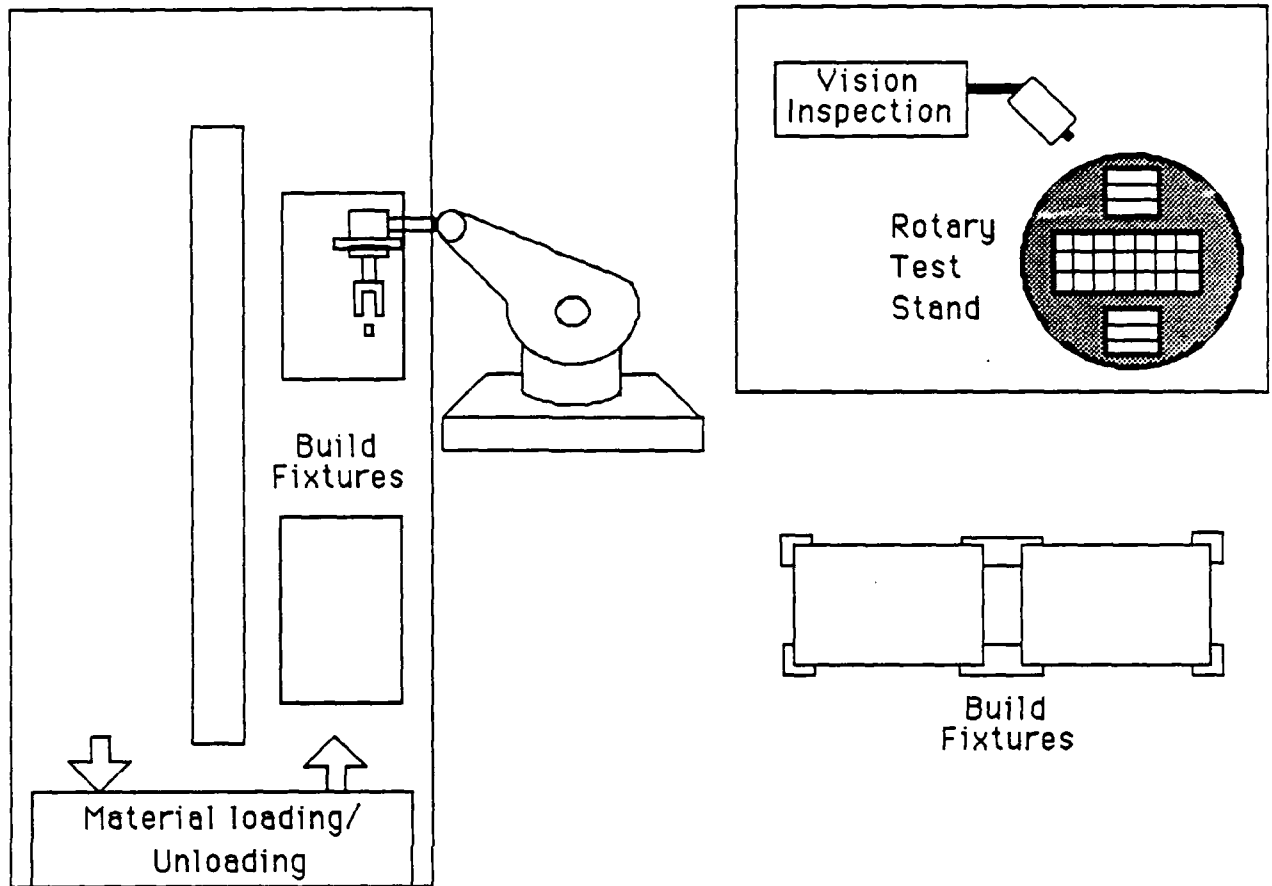
Product oriented manufacturing is characterized by grouping all functions common to an individual product in a close proximity or physical area. This means that each work area is strictly dedicated to the manufacture of individual products. In this regard, a major requirement of product oriented manufacturing is that there be sufficient capital equipment allocated to support each individual product line.

Process controls are characterized as those required specifically on a product by product basis, however production control is simplified by the single product focus. Inspection, under production oriented manufacturing, is again product oriented and is facilitated by a step-by-step process that follows the product through the production cycle. Training materials and aids must also be developed on a per product basis for each operation performed.

Material control is dedicated to each product and requires multi-point material distribution control for allocation of parts.

#### **Functional (Process) Oriented Manufacturing**

In contrast to product oriented manufacturing, a functional orientation groups processes common to all products in a physical area. This can provide an advantage for products requiring that a high degree of repetitive tasks be performed for the manufacture of the product. In that regard, while operators do not require shifting from processes, a level of sameness in the work can decrease productivity.



**Workstation:** Responsible for controlling execution of one or more linked processes  
 Directs commands for specific action to appropriate processes  
 Monitors process activity through command acknowledgements and exception alerts  
 Acknowledges work cell commands

**Process:** Responsible for executing specific steps within an operation  
 Provides acknowledgement of each command received and reports each relevant action taken  
 Reports exception conditions with respect to machine operation

**Figure 3.2.1-2 Workstation/Process**

One of the major benefits of functionally oriented manufacturing is that production resources (such as capital equipment) is centralized and requires less duplication. As part of this benefit, product flow is forced through a common location, allowing for more control and tracking of production processes. This concentration on the process allows development of universal process controls and the development of more generic work aids and training.

Material handling and control becomes more concentrated under this scenario as limited classes of material are established for each single point of use or work area. In contrast, production control must be more spread out to monitor more production points for an individual product.

### **Combined Functional/Product Orientation**

The combined functional/product manufacturing orientation represents the most common organization of characteristics in most manufacturing environments. This mix allows processes that are common to all products to be grouped in separate, distinct physical areas. In turn, processes that are unique to a specific product can be isolated in a separate physical area for more efficient production control.

The functional/product mix provides defined integration points for product/process routing splits and merges. Material handling is optimized by the ability to define specific material class requirements for each of the work areas. In addition, resource utilization is optimized due to the fact that resource orientation is defined for the most productive work flow.

### **3.2.3 Definition of ITM Project 88 Objectives**

ITM Project 88 has a defined objective to increase the efficiency of the transformer and chassis areas by the use of improved material handling systems. ITM Project 88 addresses the modernization of the factory layout of the chassis, transformer, and epoxy areas within the Flight Management and Targeting Systems (FM & TS) department. This modernization is to be accomplished through more efficient use of floor space, utilization of vertical storage and retrieval systems (VS/RS), streamlining work flow, and installation of ergonomically designed work cell/work centers.

The primary concentration of efforts for performing ITM Project 88 are focused on the overall structure and layout of the chassis and transformer areas, workstation design improvements, and improved material handling means.

### **3.2.4 Definition of Variables and Criteria**

The variables and criteria for Project 88 are used to define more discretely the areas that most benefit from material handling and production flow improvements. The variables represent the major aspects of production operations while the criteria define the ways in which improvements can be measured.

Manufacturing operations variables are those areas within a manufacturing operation that are changed or affected by changes within the operations to optimize production. These variables are defined by three major categories:

- Production
- Material
- Information

#### ***Production Variables***

*Structure.* The structure of production can be defined either in respect to the hierarchical levels defined earlier or as a specific operation's organizational structure. Organizational structures can greatly affect the flow of production, especially in the structure's responsiveness to the manufacturing flow problems and in its facility to implement modifications and changes to the manufacturing processes.

*Layout.* There are a number of ways a production area can be physically organized on the shop floor and this physical layout can greatly affect the manufacturing production flow. While this area is described in greater detail in the following section, it should be noted that there are a number of ways that a manufacturing area can be laid out but the specific layout depends upon the goals for the area and the criteria defined for that area.

*Process Flow.* In conjunction with layout, process flow can be optimized to group resources in a specific area and to consolidate material handling efforts. The definition of an optimized process flow is a major factor in defining an optimum physical layout.

*Group Technology.* Group technology addresses two major operational philosophies, one concerned more with the cellular organization of processes and work areas, and the other focusing on specific products and product families. These concepts are explored in detail in Section 3.3.

#### ***Material Variables***

*Material Management.* The effective control and management of materials is key to efficient and profitable manufacturing. Material management

encompasses scheduling materials (both raw materials and work-in-process) as well as being able to monitor material usage and production completions.

*Material Handling.* Material Handling ranges from totally manual to fully automated and the selection of the appropriate material handling methods depends upon the definition of the appropriate criteria such as product characteristics and movement distances required.

### ***Information Variables***

*Systems.* Information systems can, like material handling methods, range from totally manual to fully automated. All manufacturing processes at any level include production information systems and it is important to define systems that are responsive to the manufacture of a product and that aid in that production rather than affect it adversely.

*Control Networks.* These networks, either formal or informal, serve to monitor and control production processes more accurately, thereby allowing other operations to be targeted for improvements. With the advent of computer controlled networks, much of the lower level control functions can now be readily automated dependent upon the specific criteria for a process.

### **Production Criteria**

Production criteria are necessary for the development of any facility/operations improvement program. These criteria cover a wide range and an all inclusive list would be far too long for consideration in any project. The following paragraphs describe some of the major production criteria that have been used in the development of improvements for the FM & TS ITM Project 88.

#### ***Capital Investment (Duplication of Equipment)***

Capital equipment should be considered for duplication when product volume processed requires time in excess of 96 hours/week (greater than 2 shifts per 24 hours) or the unit is critical to production such that down time in excess of one shift would seriously impact production.

#### ***Square Footage Required (Process vs. Product)***

Consideration must be made for flow lines and/or product queues. If the area occupied by single product-related process exceeds 50% of space utilized, the process should be incorporated into product flow. This allows processes to function at peak efficiency and product specific operations to be performed in an optimum area.

### *Process Time for Separate Operations*

If process time at a remote location (including movement) exceeds one shift, it should be incorporated into the product flow. Alternatively, a facility relayout may be considered to bring separate operations together. (Obviously, the cost effectiveness of process incorporation of facility relayout is governed by product volume, available capital, and facility costs.)

### *Product Profile*

The following factors dictate product oriented assembly (versus process oriented) to avoid quality/damage problems:

- *Product Size.* Weight or volume of product precludes movement to a remote processing point without risk of damage.
- *Process Complexity.* Process employed has an intricate or extensive set of steps necessary to accomplish a particular task making it inconvenient or subject to error if intermixed with other processes.
- *Parts Count.* Unit has high number of unique parts which, by organizing in a single product workstation, ensure higher quality and throughput when contrasted with a multi-product workstation.
- *Special Handling Requirements.* Unit configuration or delicate nature dictates minimizing handling or transport during intermediate assembly steps.

### *Material Transport Related Factors*

If time taken for

- Material Movement (distance)
- Queueing time (Wait States)

exceeds 20% of actual processing time, an operation should be considered for product line orientation.

### *Personnel (Skill Level, Training, Productivity)*

Ability to specialize in one product-related process area should be weighed against impact on quality/training of combining similar operations to concentrate equipment or processes.

### *Equipment Utilization*

Process should utilize equipment to the extent that simple payback can be achieved in 1 to 2 years. Actual operational time may dictate decision to implement shared usage if significantly below 50%.

### *Ease of Implementation*

Includes training and development of assembly, test aids, and software.

### *Level of Support Services Required [Heating, Ventilation, Air Conditioning (HVAC)]*

Cost factor for consideration when expanding or relocating uses additional support services.

### *Product/Process Flow Optimization*

Factors which impact idealized (or linear) area flows must be defined. Acceptable percentage deviation must be established between idealized and actual by modeling product and process arrangements.

### *Ease of Expansion/Capacity*

Initial investment factor should allow a minimum of 20-50% increase in flow (single shift). Expandability should be evaluated on payback of process time efficiencies similar to justification for base unit (1 to 2 years).

### *Throughput*

Optimized combination of operations minimizing set-up and tear-down times so that equipment utilization is maximized for productive output.

### *Equipment Limitations*

Factored in terms of:

- Percentage of area occupied
- Percent of total utilities consumed
- Percent of increase in labor expense

to overcome capacity limitations.

### *Changeover Capability (product-to-process and vice versa)*

Key factor employed in major factory realignments. Normally encountered in multi-step equipment employing universal tooling or fixtures.



### *Viability*

Must have rational basis for justification in terms of real savings in:

- People
- Materials
- Time

### *Batch vs. Unit Build*

Primary factor is impact of set-up and typical duration of key elements like diagnostic time, tool change-out, etc.

### *Number of Products/Options Manufactured*

Line orientation will optimize mix of products and calculated percentage of options (either projected or historic).

### *Volume Impact*

Quantities exceeding 25% of total work at an operation should be considered for separate area based on accumulated weight of other factors. Above one-third, volume should be the determining factor.

### **Trade Off Analysis**

The criteria described above must be valued as it applies to each of the specific production variables. This requires selecting the most significant criteria (as shown in Figure 3.2.4-1) and developing a means of quantifying its effect on the production variables.

Once the variables and their effect on production have been defined and criteria for each of these variables has been weighted for relative importance, it is possible to develop a logical model that will aid in the cost trade off decision making process.

### **3.3 Work Area Design**

In developing improved work area designs, the specific methodology employed utilizes a great deal of production and product specific data to aid in the development of an optimum work area. General systematic layout planning methods were used in conjunction with methods developed specifically for ITM Project 88. The specific methods employed for ITM Project 88 are described in Figure 3.3-1. In general, these can be characterized in four phases:

- 1) Location
- 2) General overall layout
- 3) Detailed layout planning
- 4) Installation

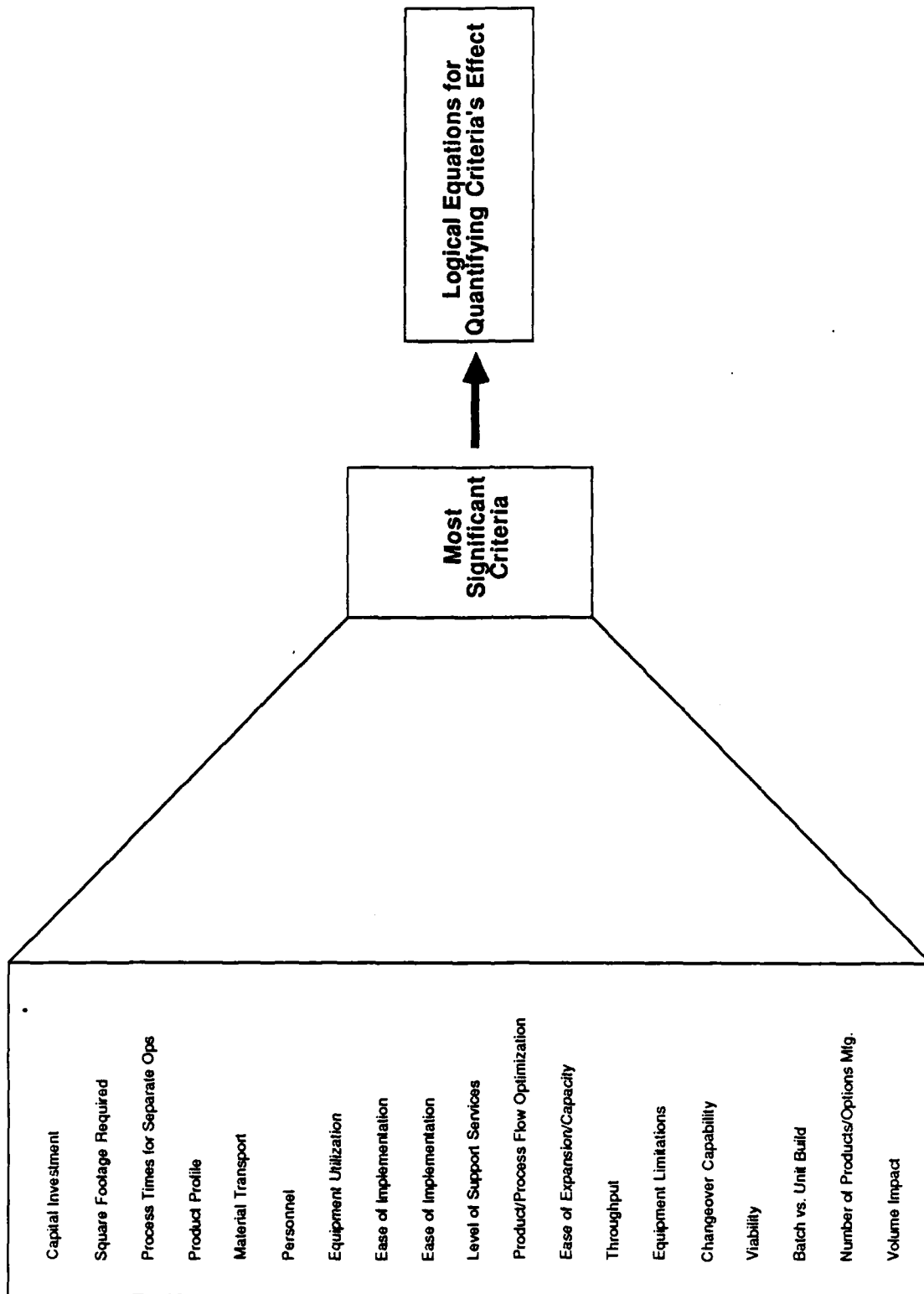
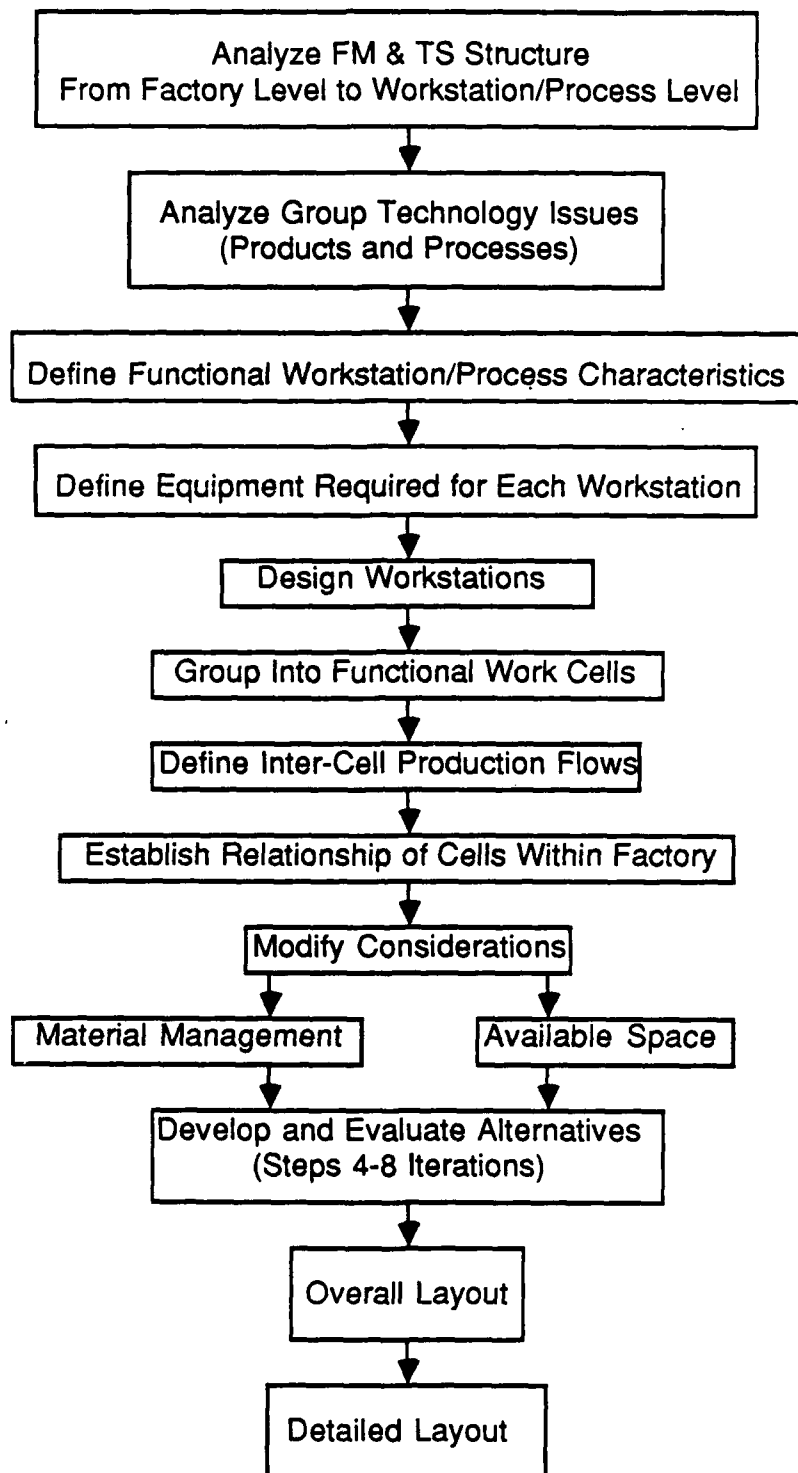


Figure 3.2.4-1 Valuation of Criteria



**Figure 3.3-1 Methodology Flow Diagram**

In addition to these four phases, five major considerations are used for systematic layout planning. Mnemonically, these are referred to by the letters PQIRST. These are defined as:

- P= Product plus variations and characteristics
- Q= Quantity or volume
- R= Routing or process (this involves both sequence and machinery utilized)
- S= Services and support
- T= Timing of PQRS (when, how long, how soon, how often)

These primary considerations are employed in all phases of the work area design.

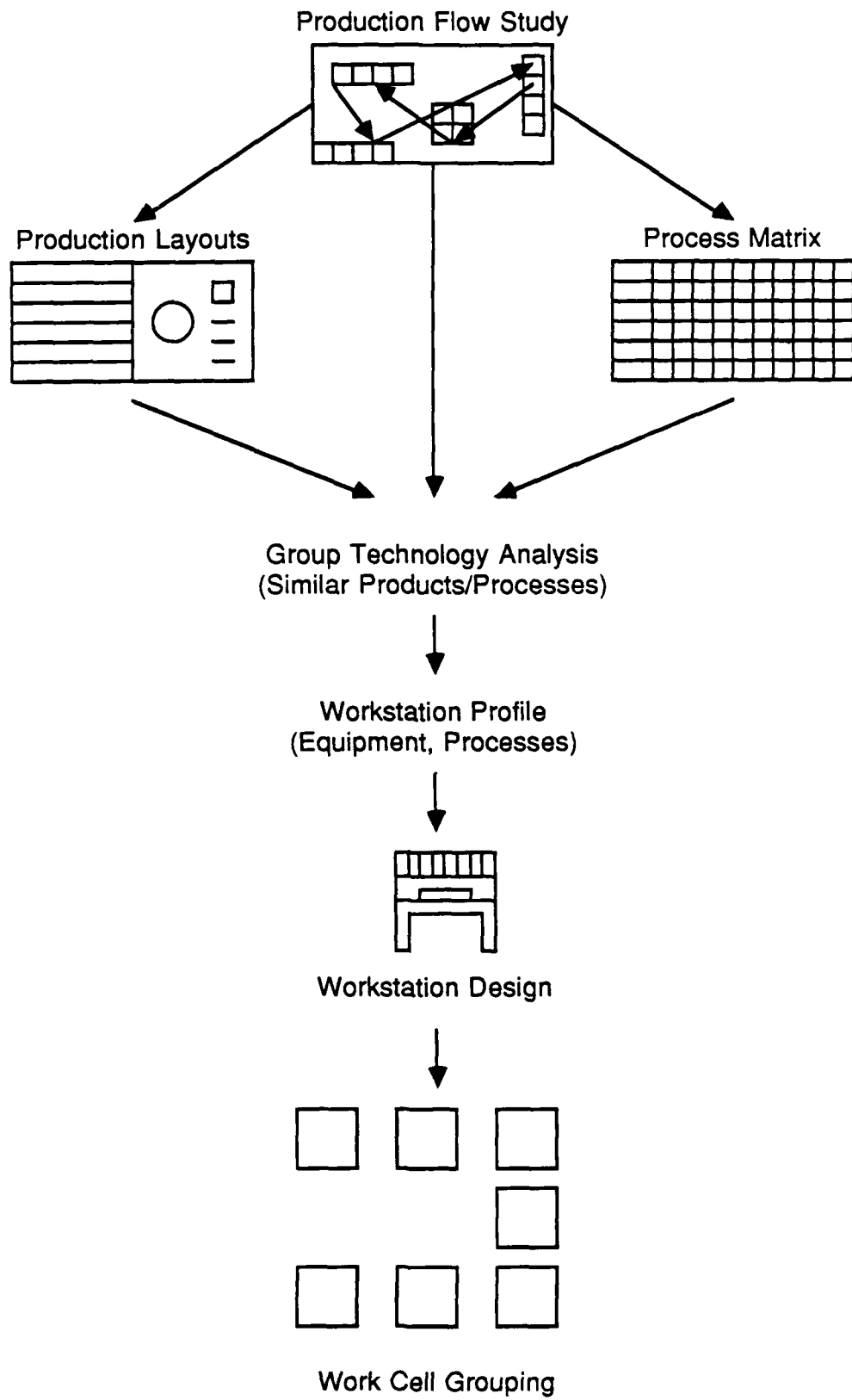
As shown in Figure 3.3-2, three primary sets of data (Production Layouts, Production Flow Studies, and Process Matrices) are used to define each work area's specific requirements along with providing some of the raw data used to analyze the applicability of Group Technology. These factors are then used to develop workstation requirement profiles which in turn lead to the development of workstation designs. The final workstations are then grouped (either functionally or by product) to develop optimized work cells.

The different variables and criteria are employed during this process at the workstation and work cell level ensure that the designs meet the overall requirements set forth by ITM Project 88. The following section provides an overview of the components employed by this methodology and how the results are developed.

A production flow study was performed by Honeywell's Tech Mod Industrial Engineering Group to document the locations where the operations called out on the production layout are actually performed in the "As-Is" operations. This provides input into determining the groupings of operations at specific workstations and work cells.

Production layouts represent some of the most important input of data to the design of work areas. Production layouts not only provide routings of the various products produced but several other important pieces of information. These include:

- Operations callout numbers and descriptions. These provide a shorthand method for analyzing how the operations fit within the routings.
- Production process details. These provide specific process details for the more complex operations called out by the layout summary. Included are references to commonly used processes detailed in supporting documents. This is key to defining the operations performed at a specific workstation.



**Figure 3.3-2 Work Area Design Methodology**

- Operation standard hours. These provide a relative method of measuring the time required to perform the called out operations.
- Fasteners/common hardware. Descriptions of all fasteners and other miscellaneous hardware used in the production process were analyzed using group technology techniques described in Section 7.
- Parts and materials. Required sub-assemblies, parts, and materials (paint, ink, wire, coatings, etc.) are listed in the layout at the specific step where required.

A process matrix was then developed to determine the hours required annually for each operation. The following methodology was employed to develop the process matrix:

- 1) Production layouts provide initial data for establishing standard hours per operation per part number. Data was correlated with operation descriptions along x axis, part number along y axis, and standard hours entered in matrix grid.
- 2) Production totals (box counts) were entered for years 1986 and 1987 on separate matrices. These were then multiplied for each part number and each new operation column was totaled (total hours per discrete operation) per program.
- 3) Production layouts were referred to subsequently for grouping operations that were (or could be) performed at a specific type of workstation. These were reviewed by the appropriate production personnel for accuracy. The matrix was then consolidated into major categories for both 1986 and 1987 production. This was then verified for 1986 using the Foreman's Cost Report (for total hours in operational area).
- 4) Business volume projections were established for the operational area and standard hours were projected for ten years using an established percentage growth for the FM & TS operations derived from FSO marketing projections.
- 5) Actual hours for each type of workstation were established using a cost variance ratio established by the FM & TS cost accounting department.
- 6) Actual number of workstations was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours/year/employee allows for 80 hours vacation, 80 hours holiday, and 120 hours for lost time (sick, jury, etc.) from the gross 2080 hours (52 x 40 hours) available each year.

Each operational area was analyzed utilizing this type of matrix to accurately determine the number of workstations and as input in developing their location within the overall area.

The workstation profiles defined during the development of the operations matrix were then analyzed for processes performed at each type of workstation. These processes and the types of fasteners, etc. used (developed in the Group Technology matrix in Section 7) then determined the equipment requirements for each workstation. A generic workstation is then defined which can meet the overall requirements of all of the possible stations for the work area. The specific equipment requirements for each station and the generic workstation design is then employed to define the configuration of each of the specific workstations for the work area.

Once all of the workstations have been designed, the grouping of the stations is laid out based upon the process flow to provide optimized routings for the majority (approximately 80%) of the product that will be built in the work area. In addition, the accessibility of resources is analyzed in relation to the work cell designs as well as the physical characteristics of the products assembled. Examples of cellular groupings are shown in Figure 3.3-3.

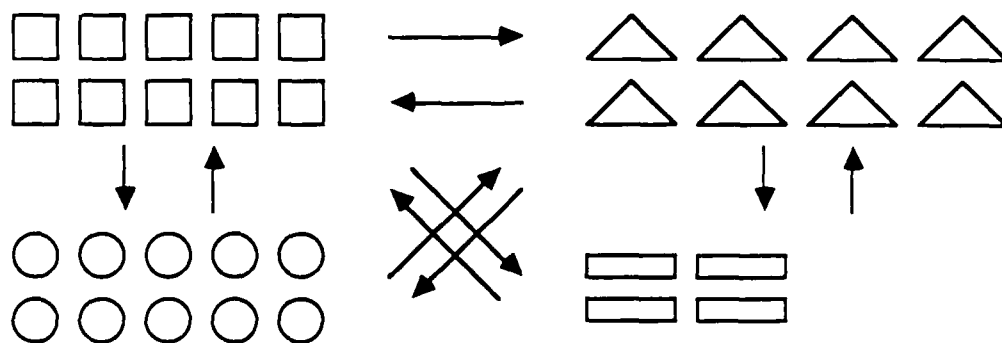
After the work cells have been developed, they are laid out for optimum routing between the cells. Once the work area has been designed, the material handling and storage requirements are developed to facilitate the process flow between cells.

### **3.4 Equipment Selection Approach**

The selection of equipment employed for ITM Project 88 was defined using a general approach and then a more refined methodology based on this approach was used for each specific piece of equipment. This general approach is described below and presented pictorially in Figure 3.4-1.

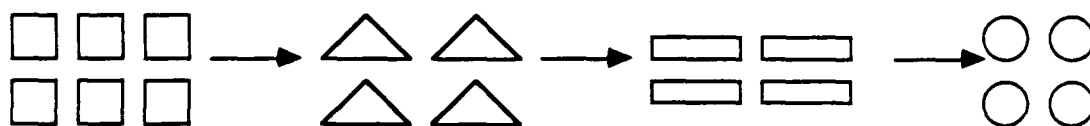
The first step in the selection of equipment is to define all of the possible equipment required to perform the process necessary for production. This was approached from several different vantage points:

- **Current equipment survey.** All equipment currently used in a production area was reviewed for functionality, age, ease of repair and availability of spares, as well as several other factors specific to the unique piece of equipment.
- **Production processes.** The processes called out by the production layouts were reviewed to determine if current equipment could adequately perform those processes and what new available equipment could be used to perform production processes.



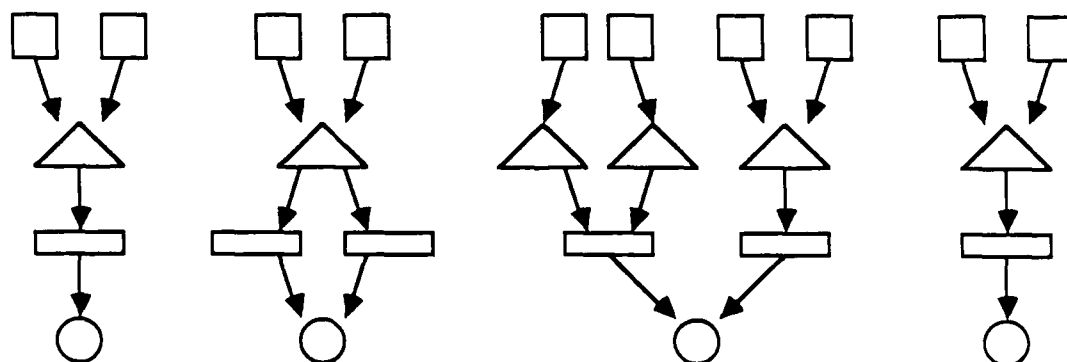
**Clustered, jumbled:**

- Clusters of generic workstations
- No attempt to organize by product flows
- No easily identifiable flow path or, organization contrary to flow path



**Clustered, flow line:**

- Clusters of generic workstations
- Organization by product flow

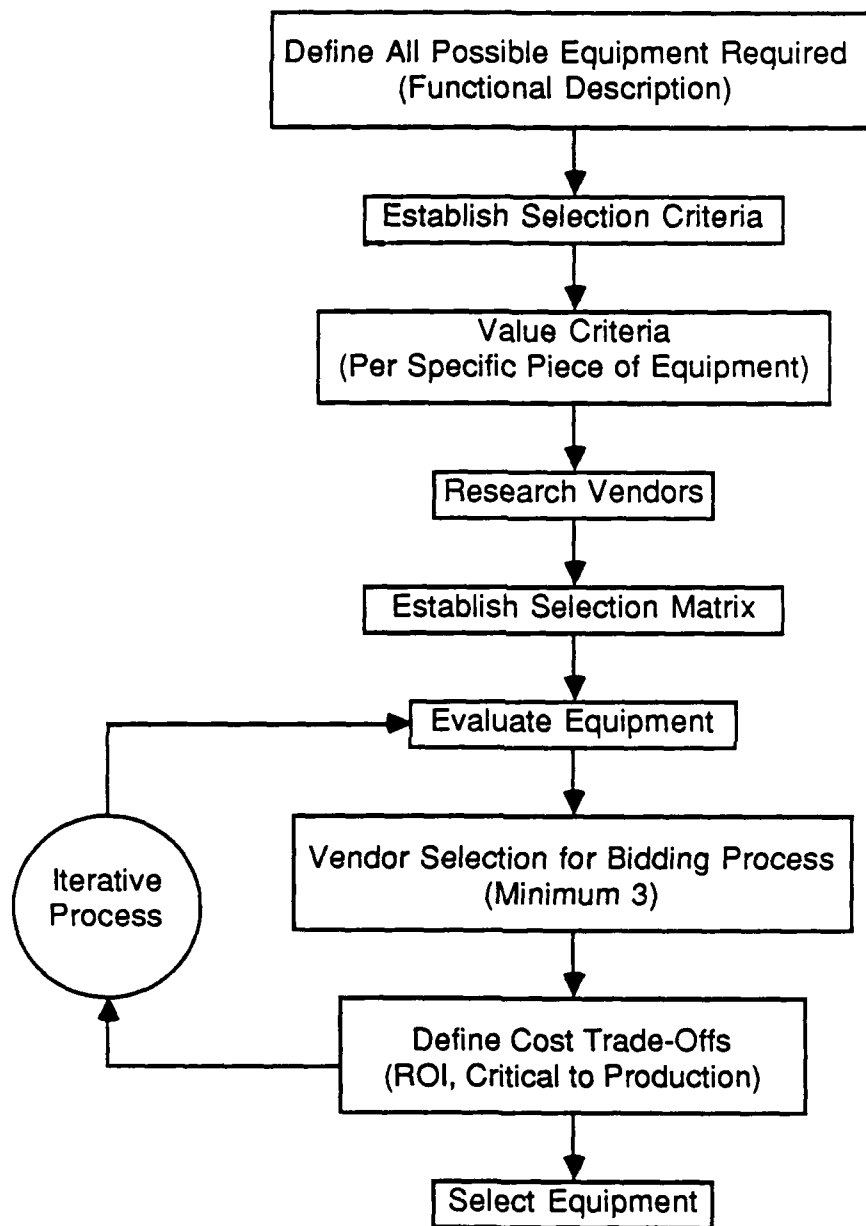


**Cellular:**

- Unlike workstations grouped into cell to produce a product family
- Only one workstation of a type, except where more needed for balance
- Cell-to-cell organization by product flow

**Figure 3.3-3 Work Area (Cell/Station) Organization**





**Figure 3.4-1 Equipment Selection Approach**

- **Technology overview.** Recent technological advances in production equipment were reviewed to ensure that during the equipment evaluation process that all applicable or substitutable technologies were understood in relation to the production area and the processes performed there.

Following the establishment of production equipment requirements, selection criteria were established to evaluate each individual piece of equipment. A general overview of these criteria includes:

### **Physical Criteria**

*Conformance to Requirements* - Equipment meets (or exceeds) capabilities required, such as capacity, frequency, accuracy, MTBF.

*Ease of Use* - Required level of technical expertise/training necessary to effectively operate equipment.

*Technology Level* - Employment of state-of-the-art features or innovative application of technology that enables user to more effectively perform intended task.

*Multiple Users* - Ability to support more than one user simultaneously (either operating or programming).

*Network Capability* - Ability of equipment to be networked to other similar units or to centralized data files or controller.

*Defect Detection and Reporting Capabilities* - Effectiveness of reporting of defects on unit under test so as to permit repair in shortest possible time.

### **Support**

*Serviceability* - Ease of maintaining equipment plus vendor's support capabilities/response level.

*Technical Support Requirements* - Level of technical expertise/training required to effectively support (program, maintain, etc.) equipment.

*Cost of Programming* - Relative effort required to develop operational programs for equipment.

### **Physical Characteristics**

*Portability/Moveability* - Effect on critical adjustments/required participation of vendor.

*Ease of Installation* - Effects on installation due to physical size, mounting/isolation requirements, vendor or customer team required.

*Ease of Upgrading/Modifications* - Convenience of installing additional capabilities/features/options as well as field changes (both hardware and software).

*Physical Interfacing* - Relative level of ease in providing interface to unit under test (UUT) or other equipment being operated on.

*Cooling Requirements* - Special HVAC requirements necessary for equipment due to operating temperature and range.

*Environmental Impact* - Provisions required due to equipment-generated heat, noise, vibration, etc.

*Power Requirements* - Exceptional or unusual power requirements equipment as compared to similar types of equipment being considered.

*Special Environmental Requirements* - Special environment requirements such as "clean" room, dark room, isolation mounting, etc.

## **Vendor Evaluation**

*Delivery* - Availability of equipment in accordance to needs.

*Vendor Reliability* - Supplier's record in delivering and supporting equipment (evaluate by questioning other users).

*Equipment Cost* - Evaluated in relation to other similar pieces of equipment under evaluation for a given use (i.e., relative cost of unit).

It is then necessary (for each piece of equipment required) to "weigh" or value the criteria, selecting the most important criteria for a specific piece of equipment. The weighted factors associated with that equipment are then used to perform an initial vendor review.

The weighted criteria is ranked for level of importance or applicability to the decision making process and listed on one side of an equipment selection matrix (shown in Figure 3.4-2). This matrix is used to evaluate the vendor's product's applicability and to screen out the vendor's whose equipment is not suitably matched to the requirements.

The vendors whose products meet the initial requirements are sent specifications (RFQ's) to respond to. Once the initial cost of the equipment is established, the selection process then becomes an iterative process of defining the cost trade-offs involved, determining if the ROI is sufficient and reviewing the criticality of the new equipment and its effect on production. The final step in this process is the purchase of the equipment and the initiation of the program's implementation.

Equipment Selection Criteria	Vendor A	Vendor B	Vendor N
Conformance to Requirements			
Ease of Use			
Technology Level			
Multiple Users			
Network Capability			
Defect Detection and Reporting Capabilities			
Serviceability			
Technical Support Requirements			
Cost of Programming			
Portability/ Movability			

**Figure 3.4-2 Tooling and Equipment Evaluation Matrix**

<b>Equipment Selection Criteria</b>	<b>Vendor A</b>	<b>Vendor B</b>	<b>Vendor N</b>
Ease of Installation			
Ease of Upgrading/ Modifications			
Physical Interfacing			
Cooling Requirements			
Environmental Impact			
Power Requirements (Normal vs. Exceptional)			
Special Environmental Requirements			
Delivery			
Vendor Reliability			
Equipment Cost			

**Figure 3.4-2 Tooling and Equipment Evaluation Matrix (cont.)**

## **SECTION 4**

### **"AS-IS" PROCESS**

The following section presents a description of the "As-Is" condition of the FM & TS operations. This includes a description of the type of products currently in production, the operations structure, the organizational structure as well as the personnel involved in FM & TS Production. In addition, the floor plans of the FM & TS Chassis and Transformer Areas are included as well as the process flows for typical products. Also included is a characterization of the material flow and information flow as well as a description of the equipment currently used and an evaluation of its suitability.

An overview of the current "As-Is" process required to produce FM & TS products is depicted in Figure 4.0-1.

#### **4.1 FM & TS Production Overview**

FM & TS Production manufactures flight control products for five major programs and produces spares for these programs as well as older programs.

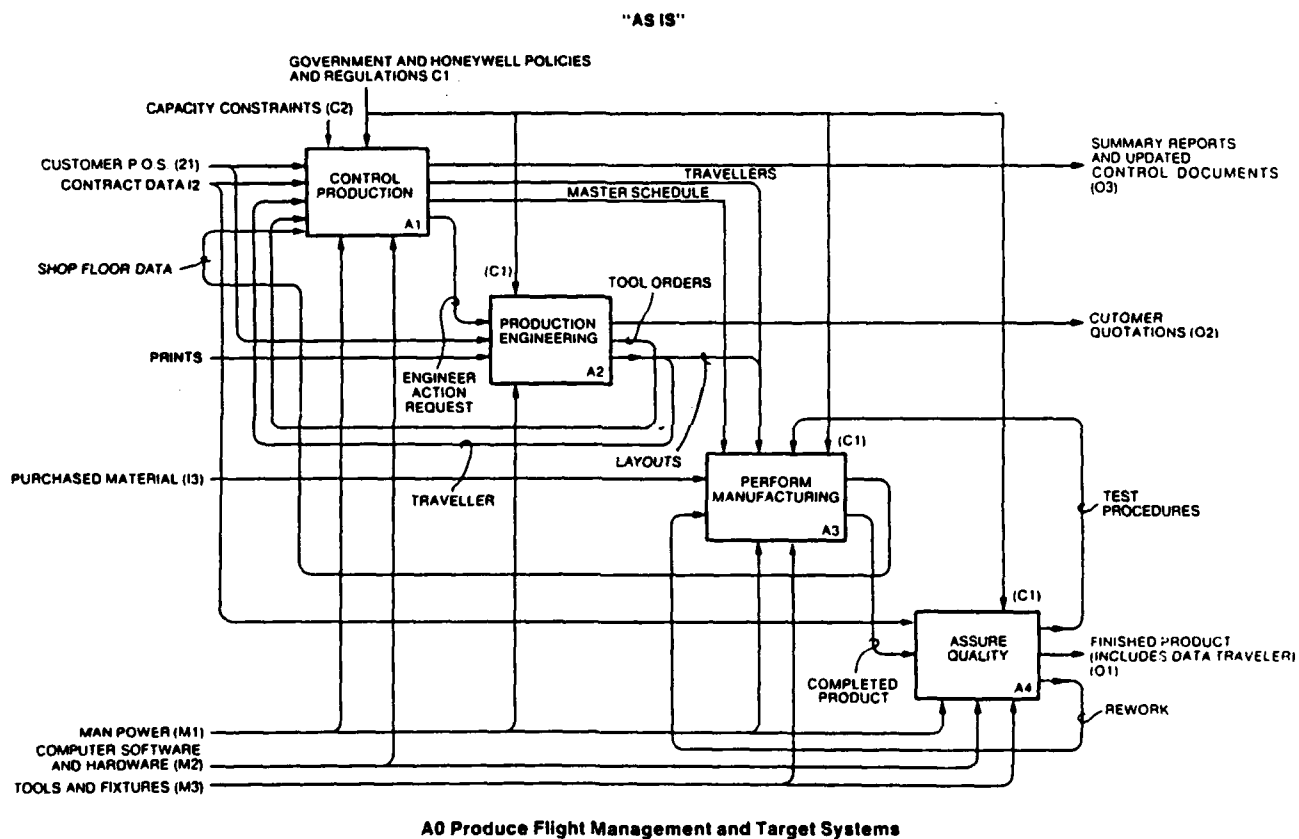
#### **4.2 FM & TS Program Profiles**

Flight Management and Targeting Systems Production assembles and tests high technology military flight control and targeting systems built under specific customer contracts. Therefore, while there may be several products within a particular program, each program must be managed and controlled to comply with a specific customer's requirements. The systems that are built under each of the program's currently under contract to FM & TS are typically made up of a variety of components, including:

- Computers
- Control Panels
- Sensors
- Control Sticks
- Electronics Units

The orders for any one of these program's products may be made for complete systems, modification packages, or spares.

In addition to the various programs, a significant amount of FM & TS Production's business is made up of military spares as well as transformers for use in FM & TS and other areas in Honeywell's Military Avionics Division.



**Figure 4.0-1 "As-Is" Production Process (FM&TS)**

### **4.3 FM & TS Operations Structure**

The following section describes the structure of FM & TS Production operations as well as the characteristics of the two areas primarily addressed by ITM Project 88.

The FM & TS Production operations structure is most appropriately described in terms of product orientation or process orientation or a mix of both at each of the hierarchical manufacturing levels described in Section 3. Briefly, the differences between product and process oriented manufacturing can be characterized as follows.

#### **Product Oriented Work Areas:**

- Allows all functions related to product to be contained in a single organization
- Requires all equipment necessary to support a product to be controlled by that product group
- Provides all necessary support functions (e.g., material handling, production planning, QA, etc.) internally
- Concentrates all activities related to product operations within close physical proximity, thereby reducing material movement
- Requires dedicated personnel to perform operational (assembly/test) tasks
- Theoretically allows compact layout but this is dependent upon the size and nature of the process equipment and product handled
- Minimizes material queuing by layout constraints
- Dedicates material handling to a product

#### **Functional (Process) Oriented Work Area**

- Concentrates assembly machinery and test equipment for shared usage (maximum utilization)
- Allows concentration of specific skills and development of technology centers
- Increases need for material movement from function to function
- Requires coordinated work planning function between process centers



- Support activities generally are provided by outside "centralized" organizations
- Layout/space utilization is generally efficient from a process/material flow perspective. Requires additional "aisle" space.
- Material queues must allow for increased transits to using areas and combined throughput rates

The definition of these two orientations provide a basis from which to analyze the "As-Is" structure of the FM & TS operations. The hierarchical levels referred to in this section are more completely described in Section 3 of this document and can be briefly summarized as:

- Factory (which is represented as the overall FM & TS Production operations)
- Work Center
- Work Cell
- Workstation/Process

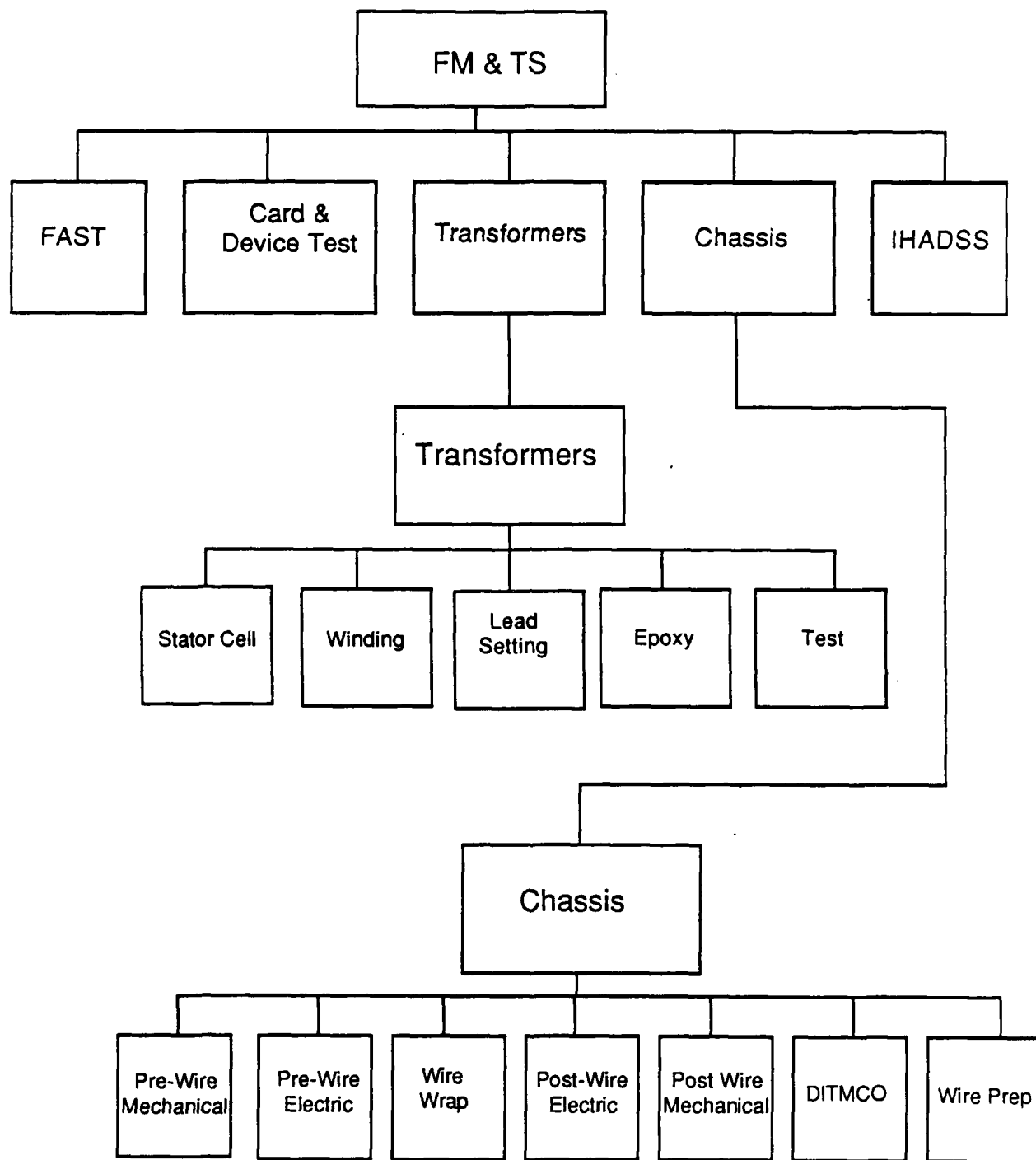
### **Work Centers**

At the work center level (as shown in Figure 4.3-1), the division between work centers reflects both a product and process mix. The primary emphasis is on process for all of the major mature programs currently under contract and on a product orientation for all of the new or variable programs. The two work centers that are of concern for ITM Project 88 are the transformer work center and the chassis work center.

The transformer work center is, in essence, a product oriented work center. It does not function strictly as a supplier of transformers to FM & TS but also produces products for several other divisions within Honeywell. The transformer work center is also responsible for the development of prototype transformers that, when incorporated into high volume products, are off-loaded to an outside vendor. In this regard, the transformer work center can be considered a low volume, high quality producer of transformers to support both FM & TS and other divisions internal to Honeywell's MAVD.

The major characteristics of the transformer work center is the grouping of all product related functions, necessary equipment and personnel, and support functions in a single organization. While it is logical that this work center should be located in a geographically central area, this is not the case in the "As-Is" condition.

The chassis work center is, on the other hand, a process oriented work center. The chassis work center is dedicated to the production of chassis and wire wrap plates for the flight management and targeting systems produced by Honeywell. While this is a low volume, high quality work center, it supports



**Figure 4.3-1 FM&TS Work Center Structures**

virtually all of the programs within FM & TS and functions as a stand-alone process center.

The structure of the chassis area work center allows for a concentration of skills and the development of technology centers. Other functions are more centralized and good coordination is exhibited in controlling the work of this process center with other dependent centers.

### **Work Cells**

The work cells within both the transformer and chassis work centers are primarily dedicated to processes. In the transformer work center, this is due to the fact that while this work center is product oriented, all of the items produced within it undergo very similar process steps that can be divided strictly by process. The only exception to this is the stators, which are wound and lead set in their own cell due to the specific nature of the processes required. These work cells are:

- Stator Cell
- Winding Cell
- Leadsetting Cell
- Epoxy Cell
- Test Cell

The work cells within the chassis work center are strictly dedicated to processes involved with the manufacture of chassis and wire wrap plates. These work cells are:

- Pre-Wire Mechanical
- Pre-Wire Electrical
- Wire Wrap
- Post-Wire Mechanical
- Post-Wire Electrical
- DITMCO
- Wire Prep

Most of the work cells that are contained within the chassis and transformer work centers can be characterized as combining all like functions in a designated location providing work space efficiency. These process cells also allow a greater focus on operator specialization as well as on process/quality evaluation of several different products.

### **Workstations**

The workstations in both the transformer and chassis area are primarily process oriented. This is typically characterized as one process per station but with the possibility of multiple products assembled at that station. Additionally, in the chassis area, some workstations are reserved for particular assemblies or models. While this multiple product orientation makes training somewhat more

complex, the expertise of the operators allows for more flexible shifting of personnel.

#### **4.4 FM & TS Organizational Structure**

The Flight Management and Targeting Systems (FM & TS) Production operations play a central role in Honeywell's Military Avionics Division's (MAvD) Flight Systems Operations (FSO) organization. The organizational structure of FSO is divided into several major functional areas, including:

- Production
- Program(s) Management
- Engineering
- Product Assurance
- Procurement

The areas within FSO are structured as independent, function-oriented organizations that report to other areas on a "dotted line" basis. Within the Production area of FSO, the organizational structure is primarily high-level-product oriented. These high-level-product related areas are divided into:

- Flight Management and Targeting Systems Production
- Missile System Microwave Production
- Printed Wiring Assembly
- Aircraft System Microwave Production
- Advanced Systems
- Central Production Services

While the divisional distinctions within FSO are primarily high-level-product oriented, the products produced by each group are also significantly distinct from a manufacturing process perspective.

The Flight Management and Targeting Systems Production operations are functionally divided into several areas, including:

- Production Engineering
- Production Control
- Assembly

These areas, which are separated organizationally, are interrelated to work together in an overall manner to support each of the products manufactured by the FM & TS operation. In that respect, each of these divisions provide input and receive assistance from the other two areas.

While the organizational division at this level is functional, the inter-division communication is defined by specific product programs. While this requires comprehensive management by each of the supervisors, it allows for

direct information exchange where it is most beneficial (i.e., for each of the FM & TS programs).

Section 4.3 presented the structure of operations within FM & TS Production and the preceding paragraphs have provided a general overview of the role of FM & TS within Honeywell's MAVD. The following sections describe in a more detailed form the personnel within FM & TS in general as well as specifically focusing on personnel within the chassis and transformer areas.

#### **4.4.1 Personnel**

Of the total number of personnel employed by FM & TS Production, approximately half of these personnel are dedicated to support services while the other half are assigned directly to production activities.

Of the number of personnel dedicated to production in the transformer area, approximately 89% are operators (in either winding, lead setting, etc.) and 11% are technicians.

In the chassis area 80% are operators and 20% are technicians.

#### **4.4.2 Group Leaders**

Group leaders are responsible for a wide variety of activities including issuing, ordering, and moving parts; assisting and training operators; maintaining production related data; and other miscellaneous activities. A study was performed by Honeywell's Industrial Engineering Department to evaluate the amount of time group leaders in the chassis and transformer areas spent performing various tasks related to their specific area's operations. The methodology for this study is presented in Section 8 of this report .

In the chassis area, group leaders spend approximately 28% of their time in material related activities (see Figure 4.4.2-1). While the categories presented in the survey results are broad (issue parts, move parts, order parts), they do not highlight the time associated with activities such as locating parts and tracking kits.

In the transformer area, group leaders spend approximately 24% of their time in material related activities (see Figure 4.4.2-2). Again, while these categories are broad, there are specific inefficiencies in this area that are hidden. Additional inefficiencies are incurred due to the lack of consolidation of the transformer area's activities.

The survey also pointed out that on an average, group leaders did not work an eight hour day, but rather ten to twelve hour days. One of the goals of ITM Project 88 is to reduce the overtime expended by the group leaders by reducing the material related activities to less than 10% of their overall efforts.

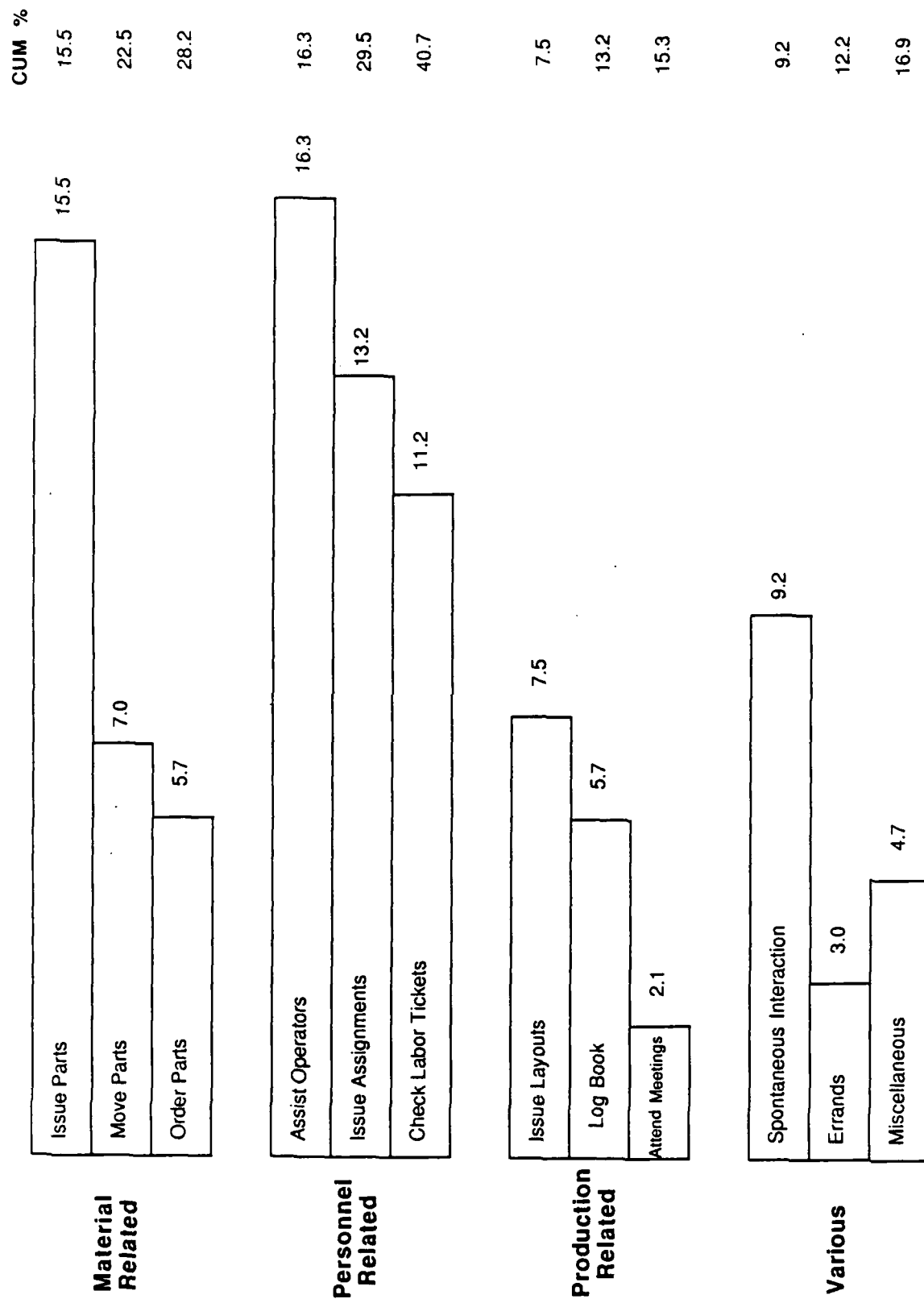
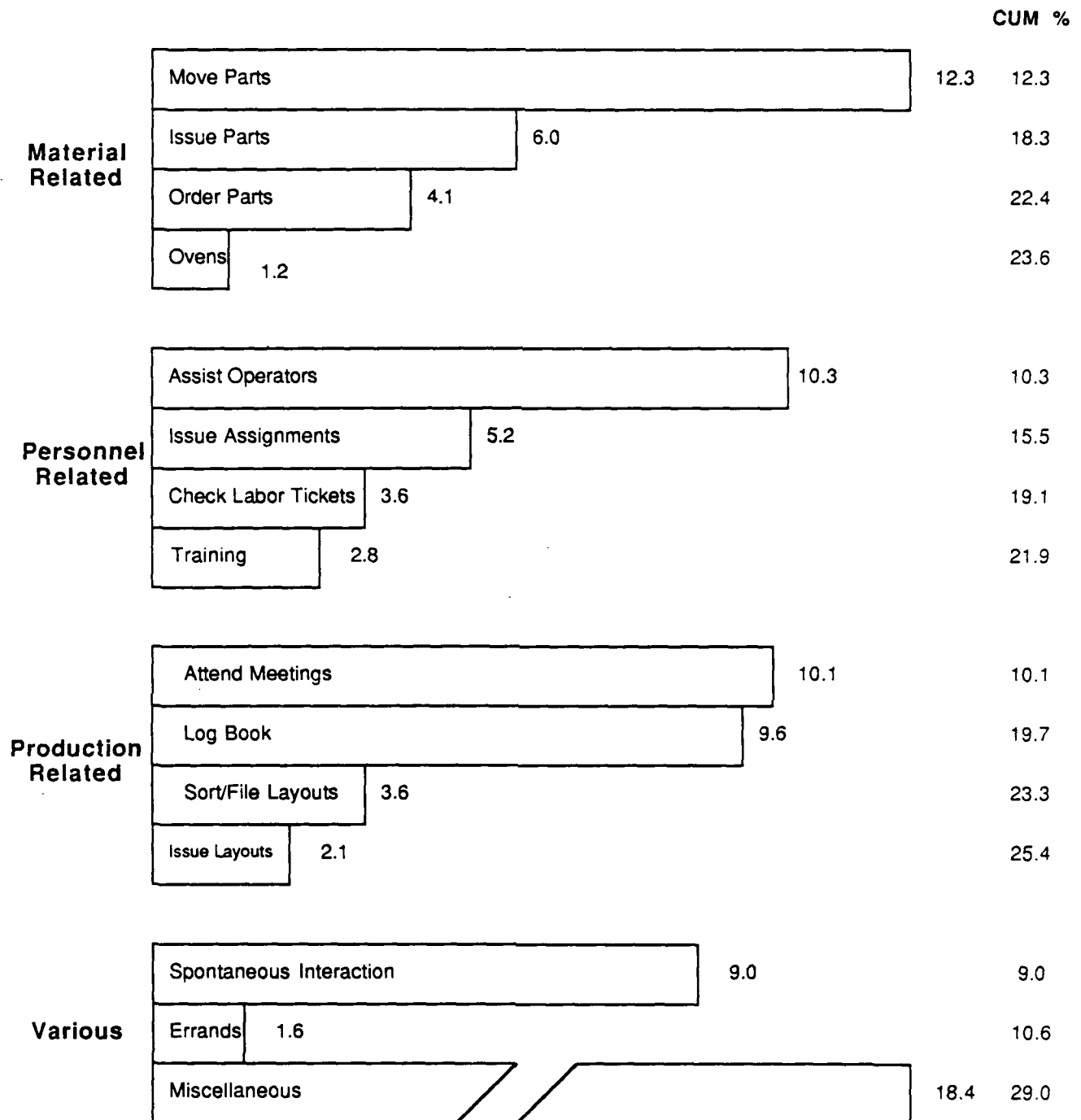


Figure 4.4.2-1 Chassis Group Leader Activities Summary



**Figure 4.4.2-2 Transformer Group Leader Activities Summary**

#### **4.4.3 Production Control**

Honeywell's Industrial Engineering department conducted a time sampling study among production control personnel supporting FM & TS activities. Out of total hours spent in support of production, the survey revealed that overall, an average of 30% of a production controller's time was devoted to materials related activities with a portion of an additional 8% (final product inspection and computer time) being material related. The Tech Mod project team reviewed this expenditure with the thought that improvements were possible through modifications in material handling and storage procedures and equipment.

It is estimated that, like a reduction in group leader time devoted to material activities, the same reductions can be accomplished with production control because the statusing and location of parts and assemblies is positively impacted by improved storage and location systems. This translates into a significant savings when extended to the total FM & TS operation.

Within the transformer and chassis areas, the reduction in time spent annually in materials related issues is estimated to be 270 hours. Extending this improvement throughout the FM & TS organization could potentially result in savings of close to 4,000 hours per year and a proportional dollar amount. This permits production controllers to utilize as much as 10% of their time on materials issues, but allows expansion into new program areas without additions to staff while maintaining the existing level of support.

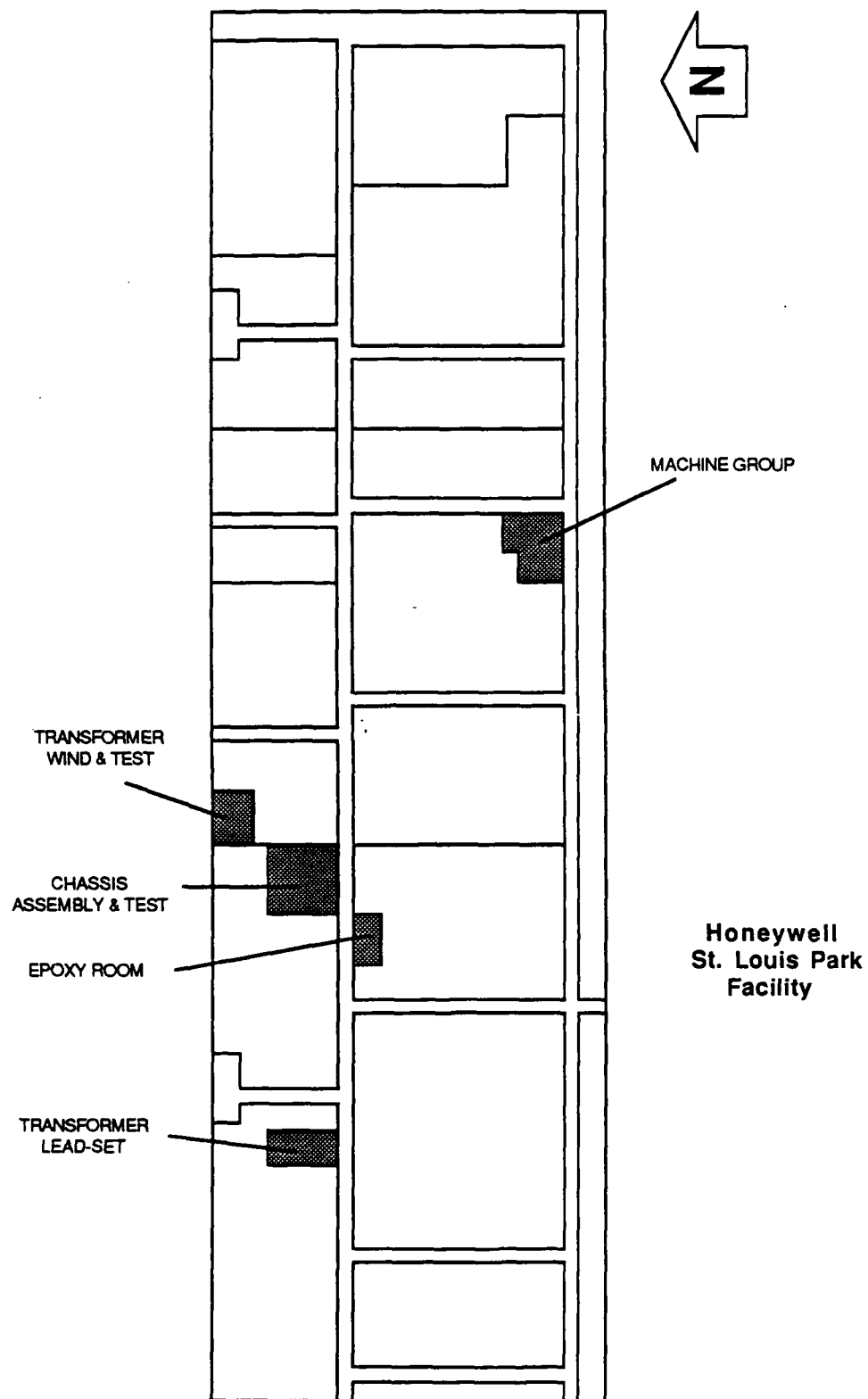
Basically, the incorporation of tracking and handling systems for material will result in significant reductions in FM & TS manpower dedicated to these tasks. As is evident in the surveys conducted within the FM & TS organization, indirect support as it relates to material is a principal cost driver.

#### **4.5 FM & TS Area Layouts**

The following sections describe the "As-Is" layouts of the overall Honeywell FM & TS Production as well as specific layouts of the chassis and transformer areas. Figure 4.5-1 depicts the location of the chassis and transformer areas within the overall St. Louis Park facility. One of the more important features that can be noted by this layout is the great distances between the different locations of work cells within the transformer work center (Wind & Test, Epoxy Room, and Lead Set).

In general, the area configurations are limited by irregular physical boundaries which inhibit the ability to design a straightforward work flow. Work "cells" or technology "clusters" are not able to be accomplished due to the work space limitations imposed by inefficient configurations and scattered storage modules.





**Figure 4.5-1 Chassis & Transformer Areas  
As-Is Location**

#### **4.5.1 Chassis Area Layout**

The chassis area is shown in Figure 4.5.1-1. The functions within the chassis group can be divided by the following groupings although these groupings are not currently used to define specific "work cells". These groupings are:

- Pre-Wire Wrap
- Wire Wrap
- Post Wire Wrap

As described in Section 4.7, "Material Flow", operations for each of the "cells" can be performed at several different workstations which requires backtracking, dead-ends, and other impediments to production flow.

#### **4.5.2 Transformer Area Layout**

The Transformer area is shown in Figure 4.5.2-1. It is especially important to note that the operations performed by the transformer group are located in three geographically distinct areas (Wind & Test, Epoxy, and Lead Set). This requires the use of the stores group to move work across and down corridors and has a negative impact on production which is described in greater detail in Section 4.7.

### **4.6 FM & TS Production/Process Flow**

Production flow is typically characterized by a combination of information flow, material flow, and process flow. For the purposes of this section, the concentration on production flow will be in regard to the specific area's process flow and subsequent sections will describe the material and information flows.

#### **4.6.1 Chassis Area Production/Process Flow**

The Chassis area process flow is graphically depicted in Figure 4.6.1-1. In addition to developing the "generic" process flow depicted here, an operations/part number matrix (described in Sections 3 and 7) was developed to provide a more specific definition of the particular product flows in the chassis area. While Figure 4.6.1-1 highlights a relatively straightforward process flow from kitting to staking and riveting to mechanical assembly, wire wrap, final assembly, and test; the actual process flow in the physical environments of FM & TS are not laid out in as straightforward a manner.

The process flow in the chassis area can be characterized by a number of factors which impede an uninterrupted process or production flow. In launching production of a specific chassis, there is a significant amount of local kitting which requires additional storage of materials and an extensive manual effort to associate documentation with materials delivered from the stockroom.

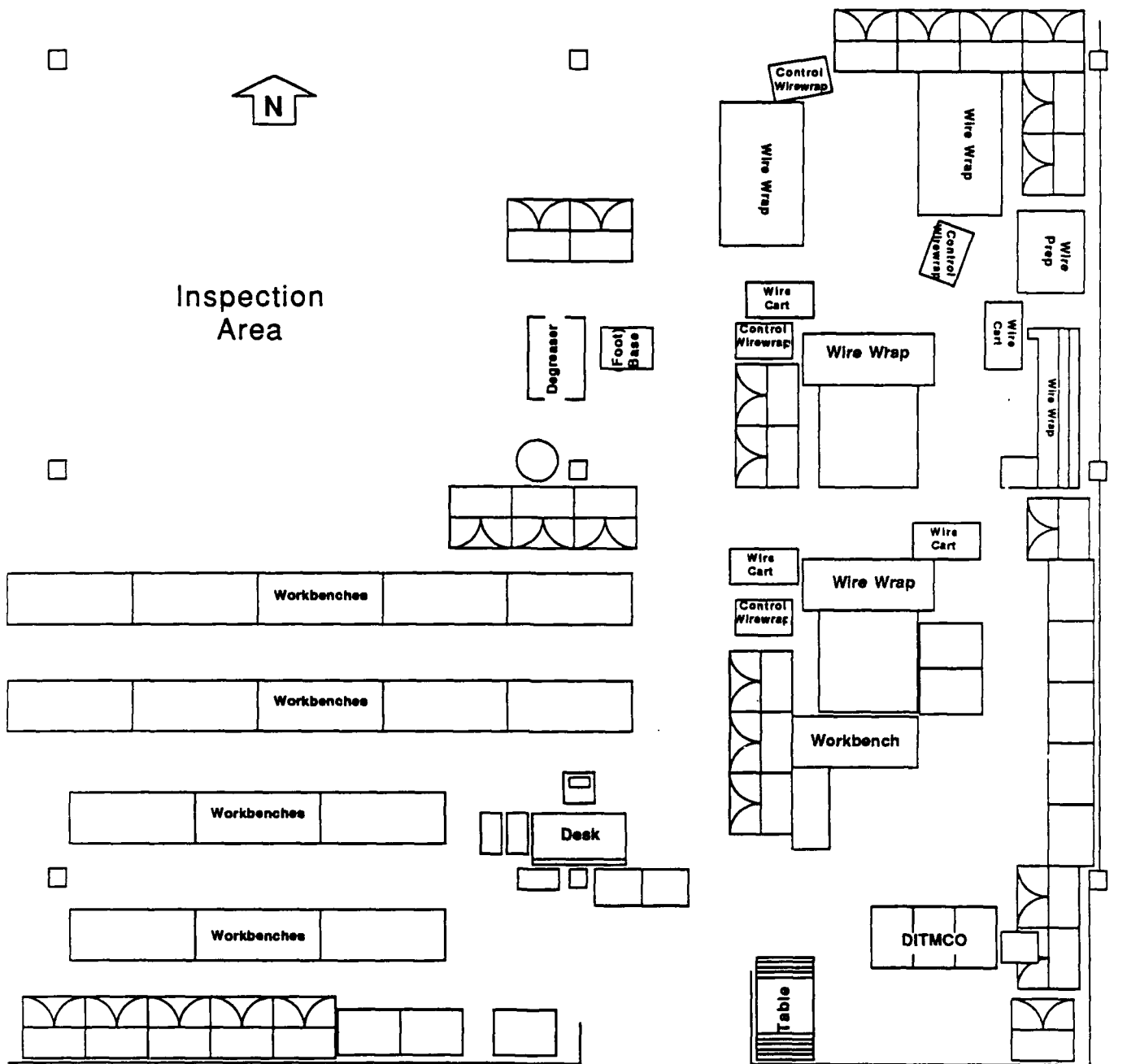
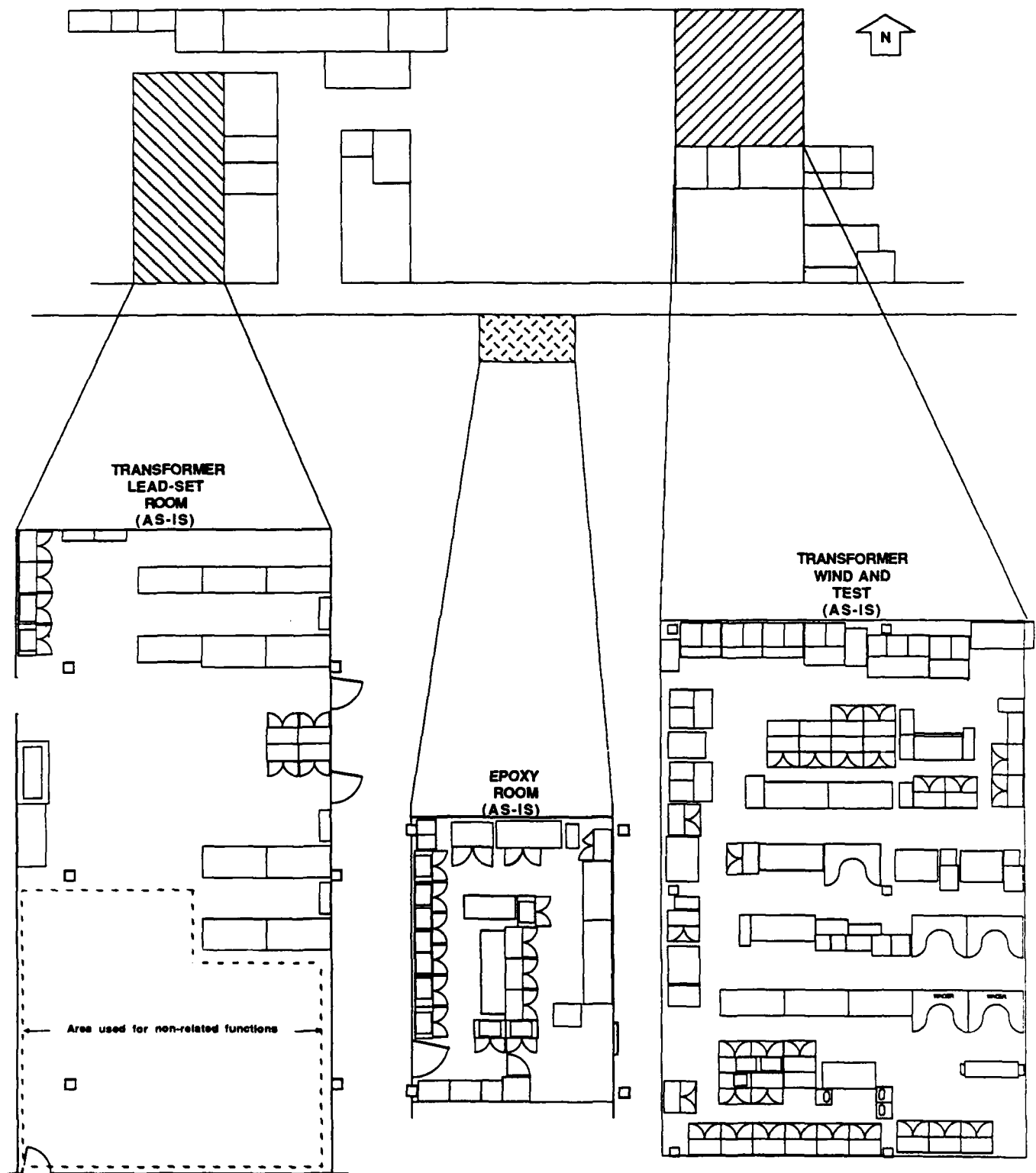
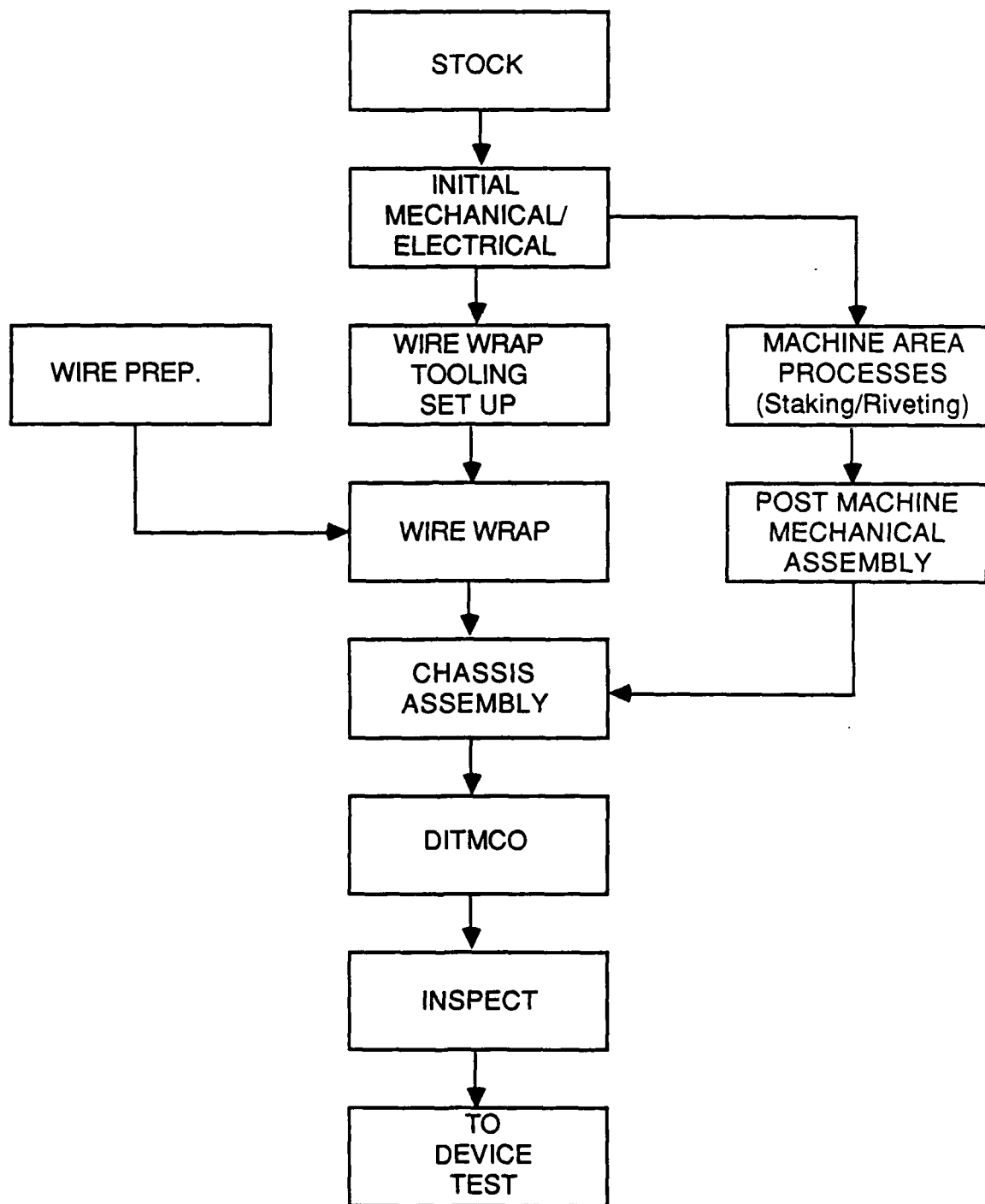


Figure 4.5.1-1 "As-Is" Chassis Assembly and Test Area



**Figure 4.5.2-1 Transformer Production Areas  
(As-Is Floor Plan)**



**Figure 4.6.1-1 "Generic" Chassis Assembly  
As-Is Process Flow**

As production continues, there are multiple material queues because the step-by-step process is inhibited by the physical constraints of the area.

In regards to the physical constraints of the chassis area, Figure 4.6.1-2 shows the flow from pre-wire wrap to wire wrap, Figure 4.6.1-3 shows the flow from wire wrap to post wire wrap operations, and Figure 4.6.1-4 shows the flow from post wire wrap to DITMCO test. It is clear from these pictorial descriptions of the production flow that there is much overlapping of activities and not a clear definition of the process flow. In general, these figures depict:

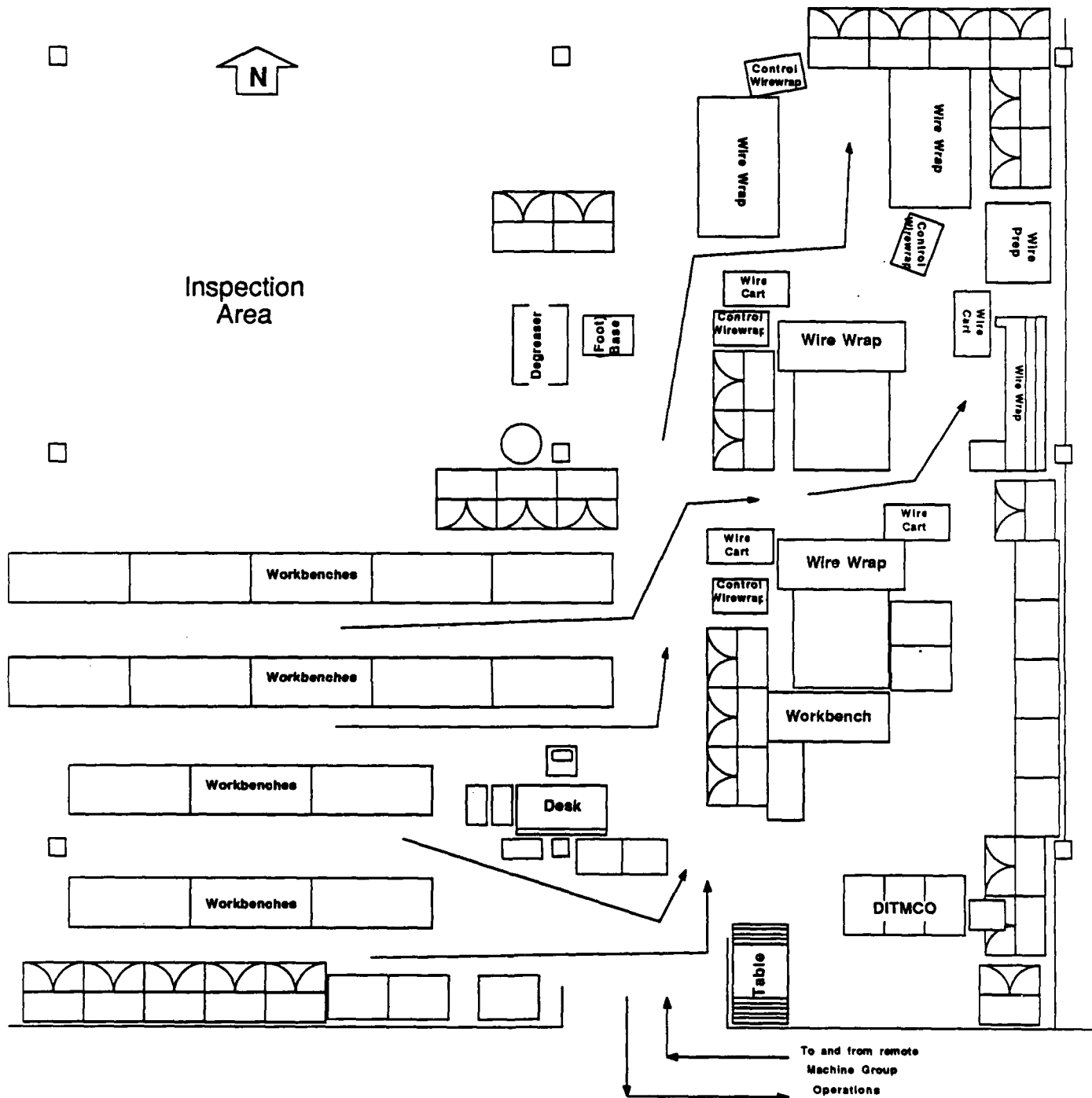
- 1) No clear dedication or specific organization of work surfaces (Any of the workbenches may be used for kitting and pre- or post-wire wrap operations depending on the chassis type being produced)
- 2) Excessive criss-crossing of the area to complete assembly operations from start to finish
- 3) Backtracking of production rather than a straight line flow dictated by processes
- 4) Tooling, materials, and prep areas require inordinate amount of movement

In addition to the physical production flow constraints within the area, there are two additional restraints which impede production. These are both characterized as remote operations consisting of machine group operations and inspection.

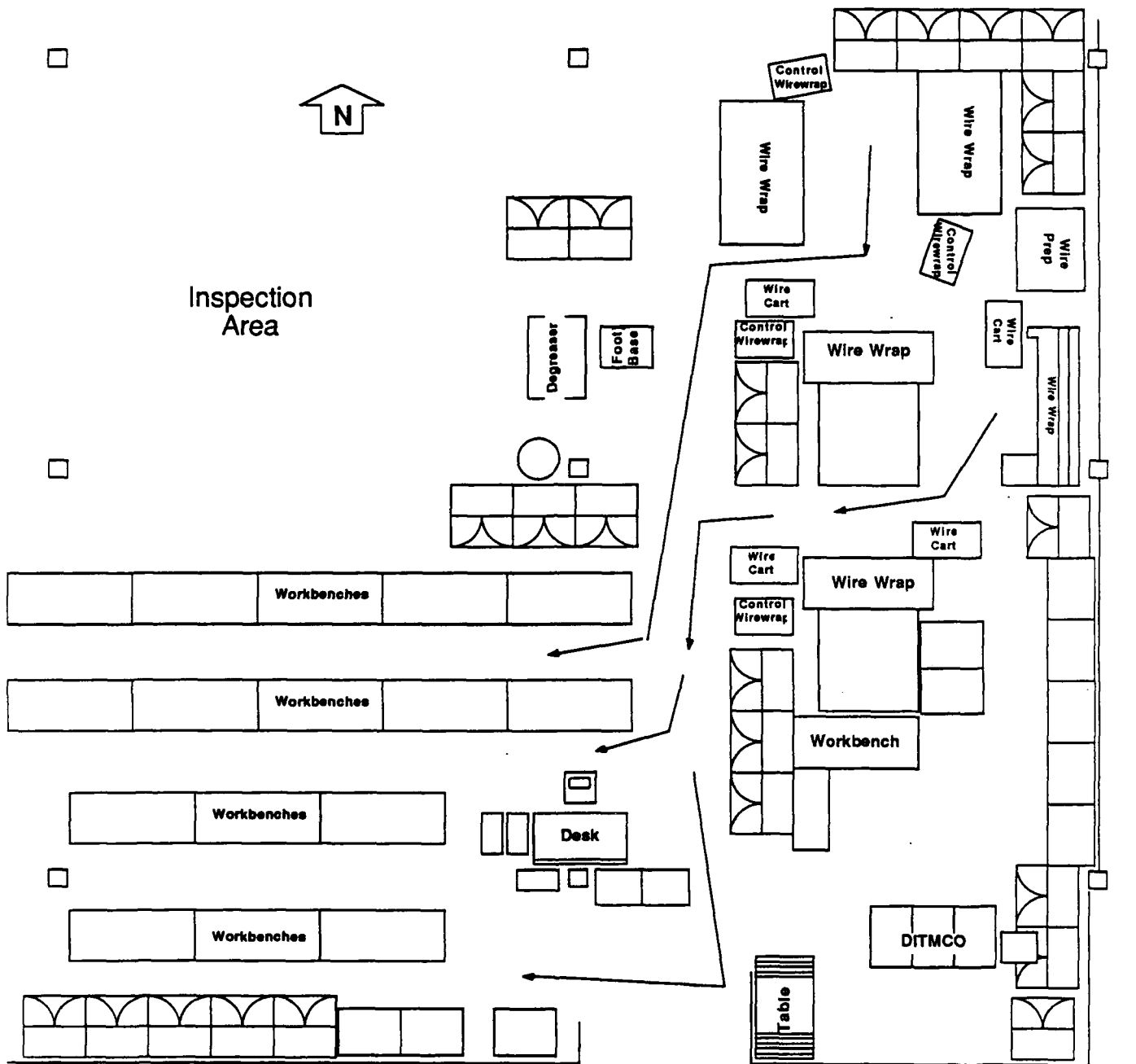
The machining operations (i.e., riveting, staking, etc.) are accomplished by a specific group dedicated to performing these operations for several Divisions within the Honeywell facility at St. Louis Park. The machine group operations include processes which may occur prior to material delivery to the chassis area or those performed initially after kitting or at some point during the manufacture of the product.

There are several constraints imposed by the "outside" machine group operations, but the greatest impact is that the group is located in a remote area approximately 550 feet from the chassis area and all production work routed there must be handled by the stores personnel in the normal course of their pick-ups and deliveries. In addition to the increased processing time due to stores, there are also delays due to the fact that the jobs from chassis are queued with jobs from other operational areas. Typically, a minimum of two weeks is allotted to process work through this group.

The inspection area is also remotely located from the process flow although not physically very far from the chassis production area. However, the location of the inspection area requires that work be diverted from the process flow to a dedicated inspection location to obtain the required certifications.

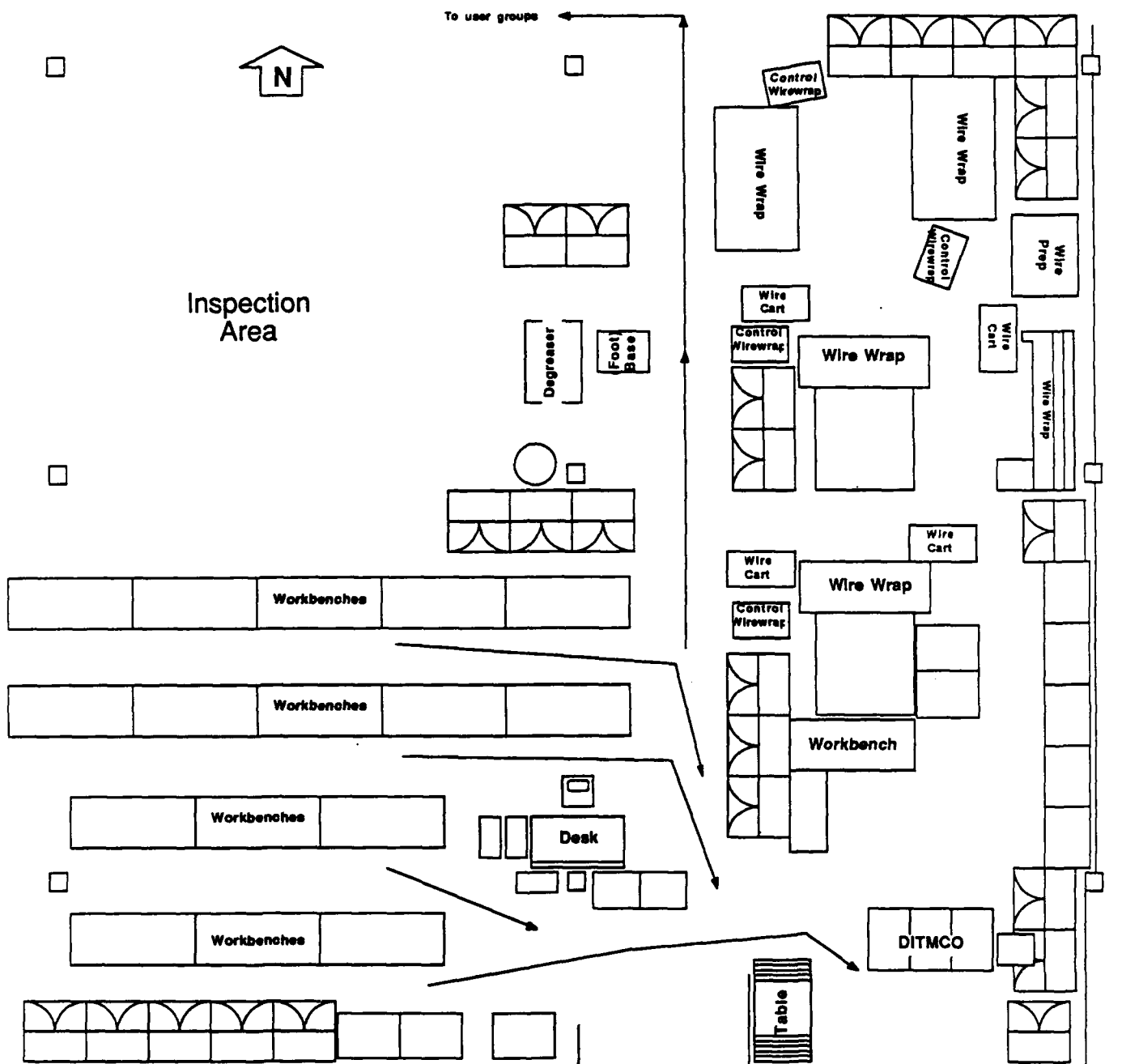


**Figure 4.6.1-2 Current Pre-Wire Wrap to Wire Wrap Chassis Production Flow**



**Figure 4.6.1-3 Current Wire Wrap to Post-Wire Wrap Chassis Production Flow**





**Figure 4.6.1-4 Current Post Wire Wrap to DITMCO Chassis Production Flow**

Inherent in this diversion to a separated inspection area is the queue time required by the inspection area of approximately two hours (maximum).

#### **4.6.2 Transformer Area Production/Process Flow**

The transformer area is characterized by the fact that while a great number of different parts are produced, they all can be typically described by a "generic" process flow. Figure 4.6.2-1 presents a pictorial description of the process flow within the transformer production area. While this description encompasses a number of individual processes, many of these are or can be consolidated and performed at individual stations or work cells. The primary operations include winding, leadsetting, epoxy, and testing.

While several operations are performed at single workstations, the physical constraints of the transformer area are significantly different and unique from those in the chassis area. Primarily, the major physical constraint on the process flow for transformers is the geographic isolation of processes. As shown in Figure 4.6.2-2, the winding and test operations are located in one separated location, the leadsetting in another, and the epoxy operations in yet another distinct location. This requires a great deal of manual tracking of production as well as the movement of production across corridors by the stores organization.

In addition, the geographic separation of the transformer areas increase queue time between processes and makes scheduling a much more time consuming task. This particular process flow also requires that a number of flows criss-cross which introduces even longer queues.

#### **4.7 FM & TS Material Flow**

The material flows for both the chassis and the transformer areas are presented in the following section. In general, a number of characteristics can be stated regarding both the transformer and chassis area material flows. One of the major impediments to a smooth material flow, also highlighted in the previous section discussing production flow, is that areas within both chassis operations (machine group, inspection) and transformers (wind and test, leadset, epoxy) are separated geographically. The impact of this on material handling is due to the fact that each of these areas is separated by an "aisle" which, by bargaining unit work rules, requires transport of work-in-process by the Honeywell stores organization.

The transport of material by the Honeywell stores organization not only incurs delays in the transit time between these areas but also several other factors, including:

- 1) Possibility of damage to work-in-process in transit between the various production areas
- 2) Increase in queue times from process to process

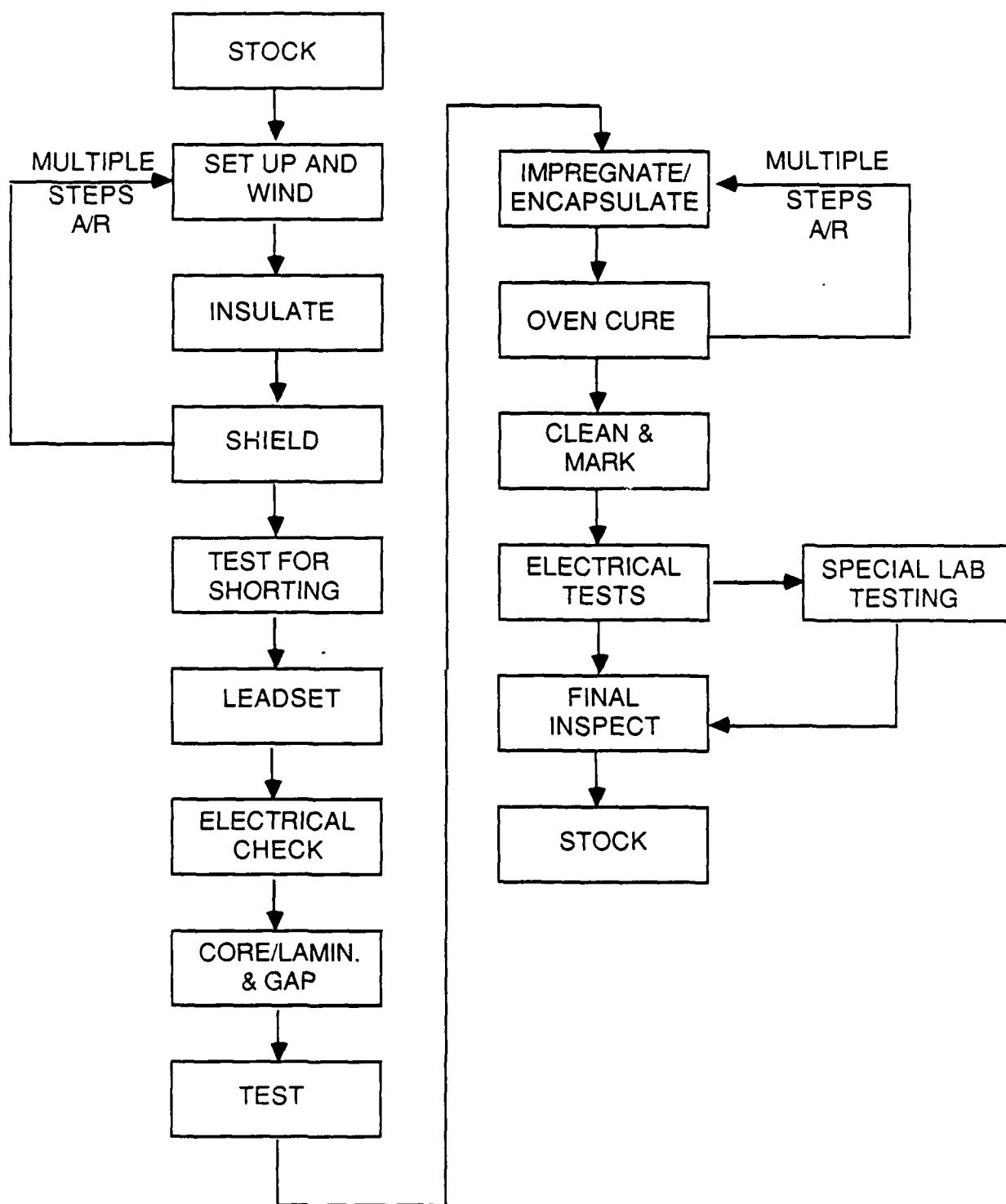


Figure 4.6.2-1 "Generic" Transformer Assembly  
As-Is Process Flow

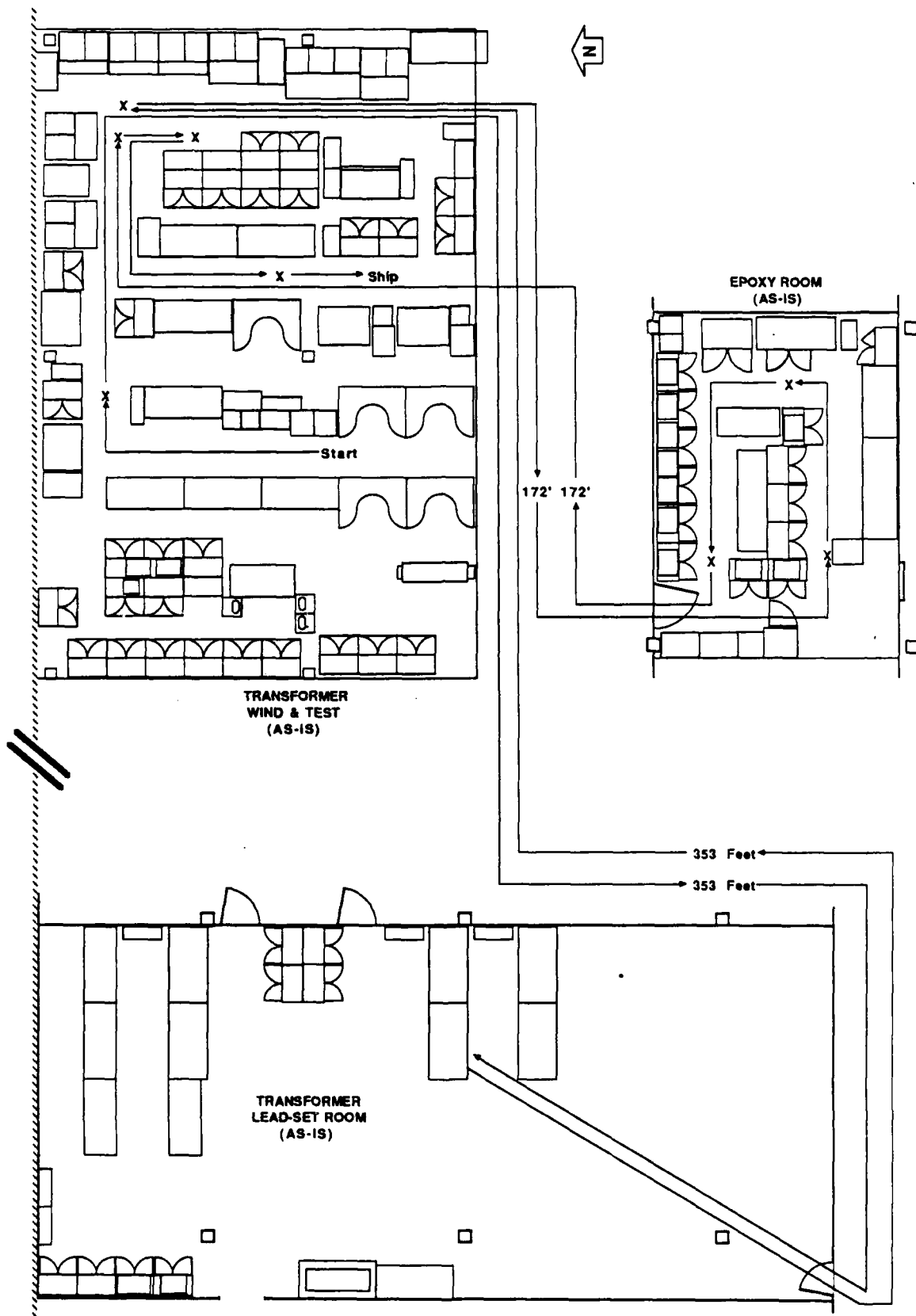


Figure 4.6.2-2 Typical Transformer Production Flow

- 3) Inability to define exact scheduling parameters which requires additional carrying of inventory to assure product build
- 4) Additional efforts required for manually tracking material and work orders
- 5) Increase in lag time for operators transiting from area to area

A simplified view of the material flow and movement requirements is presented in Figure 4.7-1 for the chassis area and in Figure 4.7-2 for the transformer area. While these figures do describe a "generic" material flow, they do not highlight the material movement means required for this flow or all of the remote operations required for processing production for a number of programs.

The primary means of material movement, whether to other areas or internally within an area, is manual. While manual material movement does not greatly impact the material flow, another feature of the areas does. This is the method for material storage.

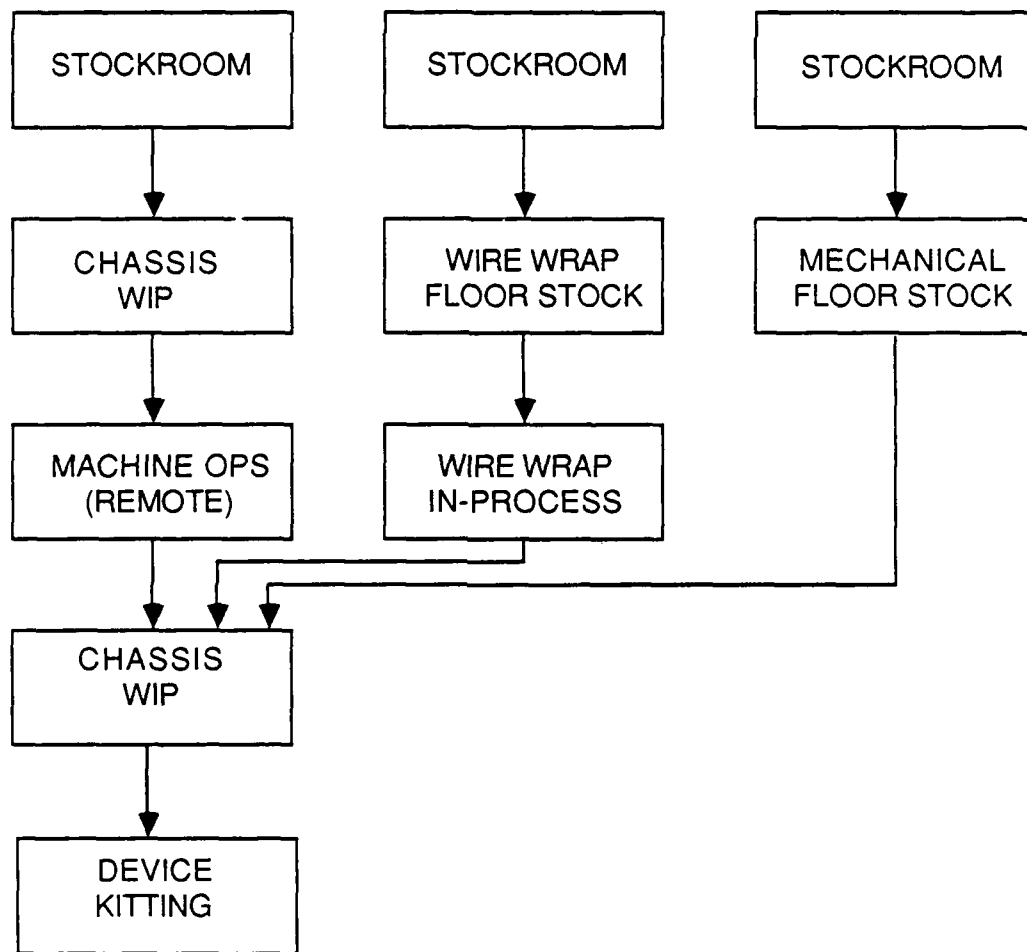
Currently, material storage in the chassis and transformer areas is performed in a space wasting and time consuming manner. The primary storage areas are cabinets, shelves, racks, under counter of workbenches, and even on top of workbenches when no other space is available.

In the chassis area "As-Is" configuration, over 1,000 cubic feet is devoted to storage of all types, including fixtures, wire wrap plates, queued material, work-in-process, fasteners, wire, repair parts, etc. Also in the chassis area, material is transported manually by the group leaders or operators. While this is disadvantageous from the perspective that it interrupts the operators or group leaders ability to focus on more important tasks, it also provides them the opportunity to stockpile parts under benches and in other areas. Operators must additionally interrupt their work to locate smaller parts (fasteners, pins, etc.) which are located in a central area within the chassis operations.

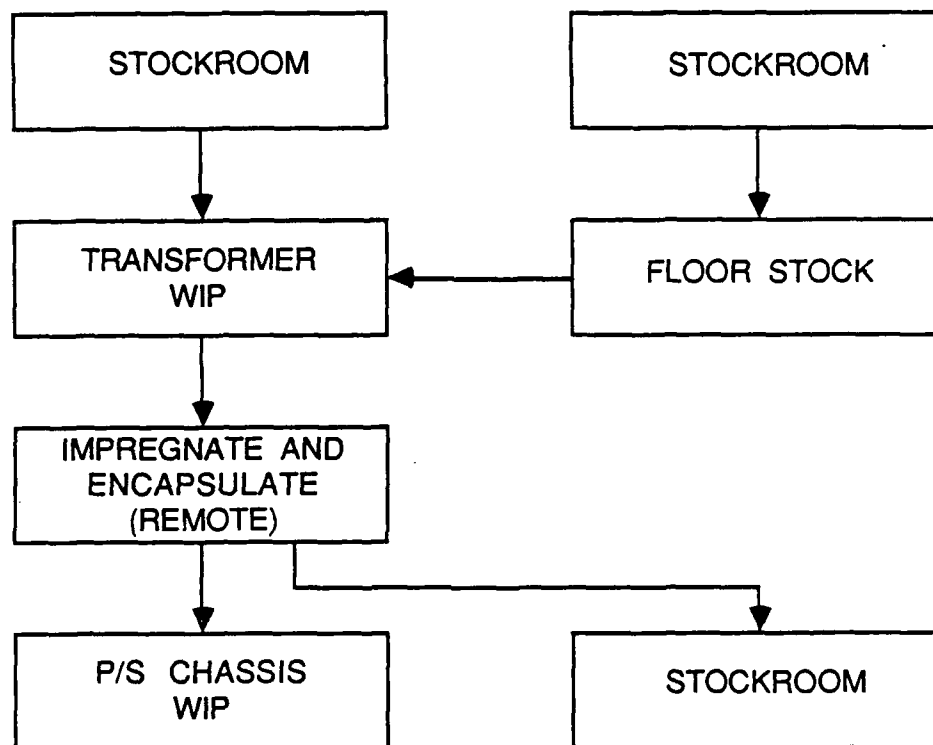
In the transformer area "As-Is" configuration, approximately 950 cubic feet is devoted to storage of wire and other winding materials. The storage of all of these materials is contained in cabinets distributed throughout the operational areas. There are seventeen large cabinets and over twenty "under bench top" shelves used to store assembly, leadsetting, and epoxy materials. In total, there are over forty-eight individual storage locations within the three transformer operational areas.

#### **4.8 FM & TS Information Flow**

The information flow within the FM & TS chassis and transformer areas is a blend of manual and automated, or "computerized", systems. Primarily, the



**Figure 4.7-1 Chassis Assembly and DITMCO  
As-Is Material Flow**



**Figure 4.7-2 Transformer Assembly and Test  
As-Is Production Flow**

higher level systems (which are used company wide) are the systems which have been computerized and the controls and systems in place on the factory floor are primarily manual. The only exception to this distinction is the ATE Central, an integrated testing facility whereby programs are downloaded to specific testing devices. However, the testing performed in the chassis and transformers areas is not integrated with this system.

#### **4.8.1 FM & TS Computerized Information Systems**

The primary computerized information system currently at Honeywell is the GAPOS/BOS system. While this is currently in the process of being phased out and replaced by the HMS/BOS system, the functionality of the two systems appears to be approximately the same even though the HMS system will provide a more efficient and powerful computing environment.

GAPOS is a high level business system consisting of a total MRP financial-based computer system. Unlike HMS, GAPOS does not collect any data directly from the shop floor and all of the data transmitted to the shop floor is in the form of paper documentation.

The GAPOS system consists of several modules that are dedicated to specific areas within the system. A block diagram detailing the interrelationships of these modules is presented in Figure 4.8.1-1. The GAPOS system consists of several modules, including:

*Bill of Materials* which includes all part information for all products manufactured by FM & TS as well as the structures of those products.

*Production Process* which contains all of the operations descriptions for processes required for manufacturing at FM & TS as well as the production routings of those products.

*Financial System* which includes all areas concerned with general ledger, payroll, etc.

*Procurement Systems* which includes all vendor data, purchasing functions, etc.

*Customer Order Schedule* which processes all customer orders (both booked and forecast) and provides a summary of total product needs.

*Production Schedule Analysis* which summarizes customer order and marketing forecast requirements; calculates and updates schedules, allows for manual adjustment for leveling schedules and economic order quantities; provides input to Inventory Control Analysis module, and promise feedback to



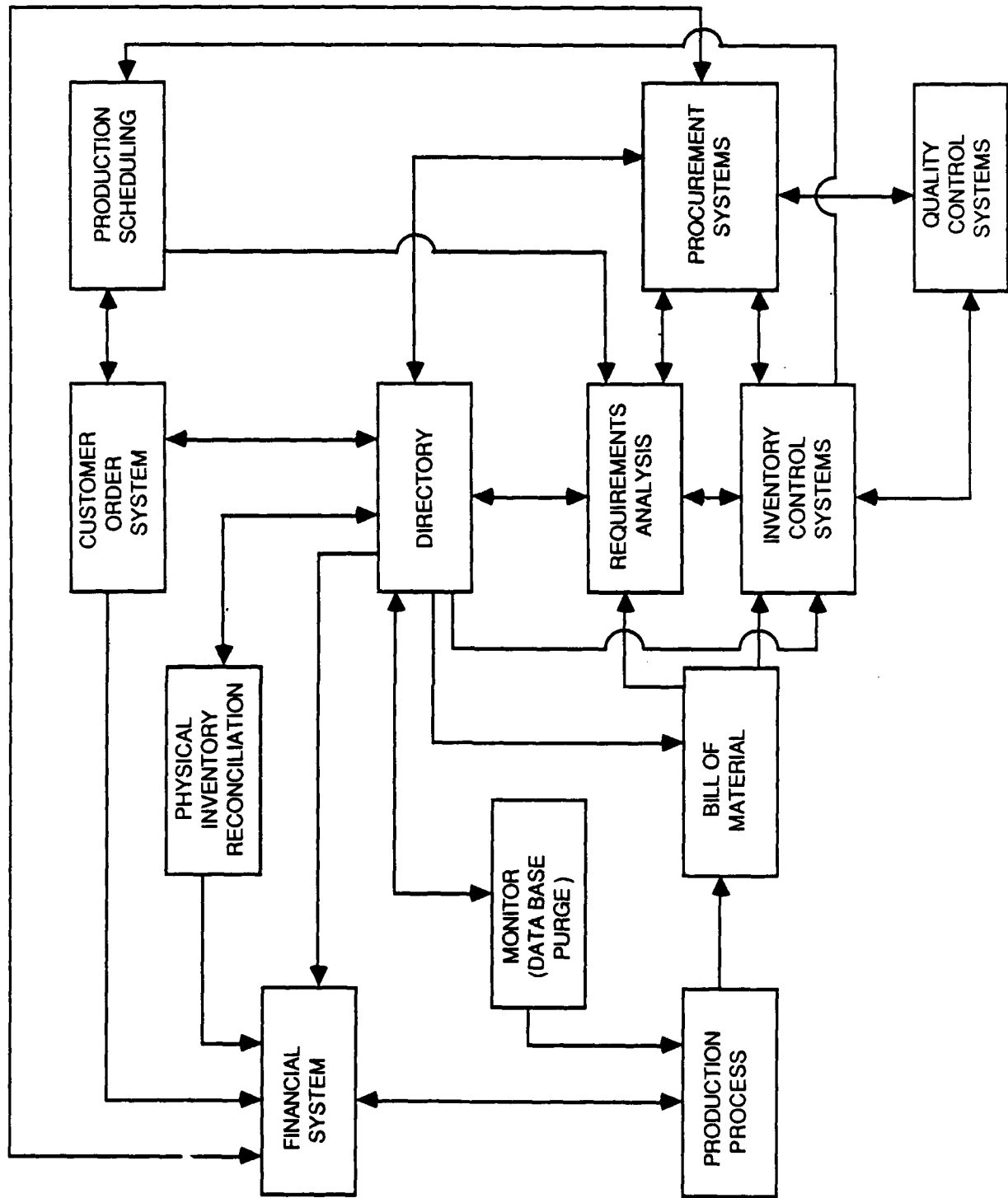


Figure 4.8.1-1 GAPOS System Block Diagram

Customer Order Scheduling; and records accomplishments against schedules.

*Production Planning and Inventory Control* modules which converts production schedules for devices and spare parts into requirements for component assemblies and parts and provides sub-assembly schedule requirements by week.

A more detailed description of the generation of the computerized schedules is provided in Figure 4.8.1-2. In this scenario, projected sales and booked orders are fed into the Customer Order System where they are processed and sent to the Production Schedule Analysis module. Here a schedule is generated for the completion of an end item ordered and the order is then released to the Requirements Analysis module which explodes the Bill of Material for all of the items scheduled and processes orders for the required materials.

Following processing by the Production Schedule Analysis module, the end-item schedule is sent to the Production Line Scheduler for manual balancing of the schedule for possible changes dependent upon schedule requirements already developed. The sub-assembly schedule, generated after the requirements analysis has been performed, is sent to Production Planning for the development of more discrete schedules and coordination of material delivery and manufacturing releases.

Other computerized systems within the FM & TS chassis area are used to prepare wire wrap and DITMCO programs for the control of the wire wrapping and testing performed in the chassis area. These systems are stand-alone and are stored on local media used at the individual pieces of equipment.

#### **4.8.2 FM & TS Manually Based Information Systems**

Most of the systems utilized on the shop floor for such tasks as production tracking and control, inventory control, etc. are manual, paper-based systems. Manual tracking of work-in-process on the shop floor is performed utilizing several aids, including:

*Mats.* These are primarily scheduling status sheets which track the manufacture of sub-assemblies (characterized by a specific operation routing/layout sheet) by number of completions by scheduled lot. Production mats are the primary scheduling and tracking devices used on the shop floor.

*Labor Tally Sheets.* As their designation implies, these are used to track the labor charged for work on a specific sub-assembly or assembly as well as to track the type of work that was performed (i.e., manufacturing process, rework, troubleshooting).

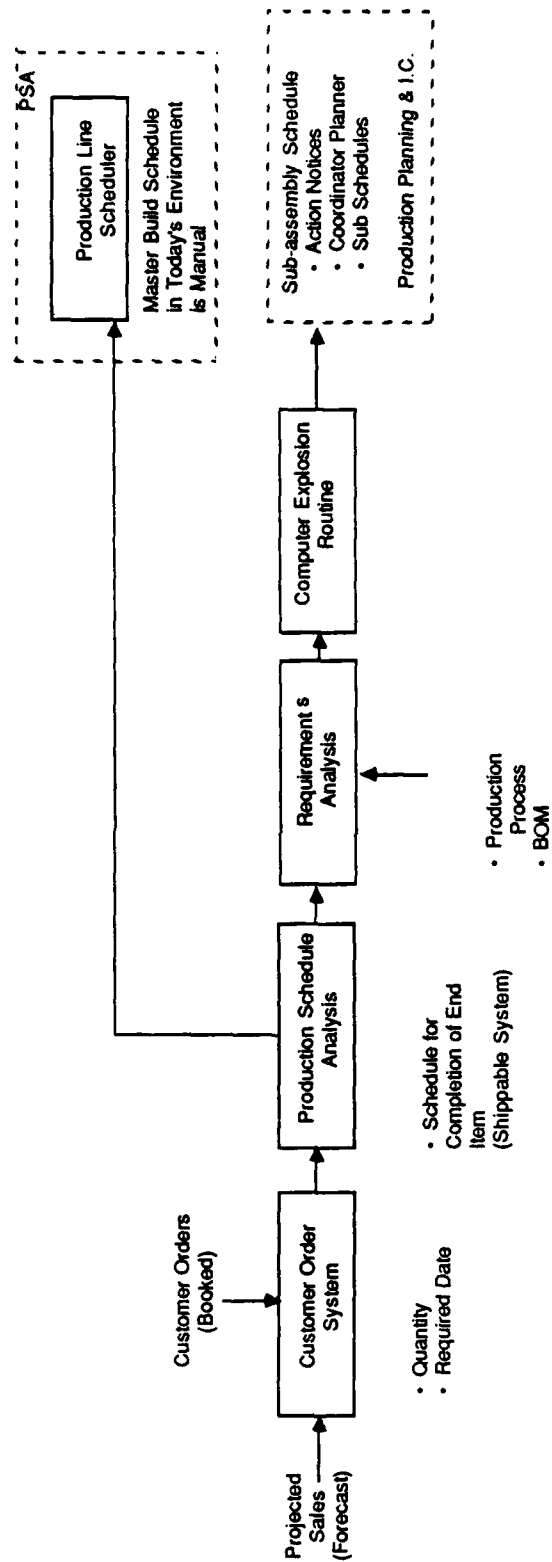


Figure 4.8.1-2 Computerized Schedule Generation

*Hot Lists.* These are used to prioritize the processing of scheduled parts on the shop floor and include blue tags, red tags, and short interval scheduling lists.

The statusing information derived through the use of these production tracking aids is used as feedback to the GAPOS/BOS system. This feedback, however, only occurs at major completion intervals such as the completion of a finished sub-assembly or a device final assembly. This allows both for build-ahead (which results in increased inventory carrying on the shop floor) as well as stocking of finished sub-assemblies until they are scheduled to be completed.

Additionally, some process data is recorded on the shop floor. Primarily, this is in the area of burn-in and test data. Burn-in data is, for the most part, manually generated and tabulated. Several ovens are equipped with temperature cycle recording, but this is not integrated between burn-in ovens and, more importantly, there is no direct feedback from an oven when a setting is out of specification.

Test data, both from the equipment in the transformer area as well as the DITMCO equipment utilized in the chassis area, is primarily collected at the station and is not interfaced to a centralized facility as are the Honeywell ATE testers, which are used for PWB and device testing. All of this equipment is monitored manually. Since units such as the DITMCO and wire wrap machines are computer or controller driven, the result is "islands of automation" because no linkage exists to a centralized database or control facility.

#### **4.9 FM & TS Equipment**

The equipment employed in the chassis and transformer areas can be generally characterized as older (though proven) equipment that has remained in place for several years. The primary reason for this is that while certain programs are relatively new and employ advanced technologies, the assemblies which are being built in the chassis and transformer areas are more basic and rely on fundamental, established processes.

The following sections describe the equipment currently being used in manufacturing in both the FM & TS transformer and chassis areas. Included is a description of the equipment, applications, and other specifications as they apply to the specific pieces of equipment.

##### **4.9.1 Chassis Area Equipment**

The equipment currently used in the chassis area consists of equipment used for mechanical and electrical assembly, wire wrapping, testing, and several miscellaneous operations. Also included is a characterization of the equipment being used by the mechanical assembly machine group which is not under the direct control of the chassis area.

### *Mechanical Assembly Equipment*

Equipment required for mechanical assembly consists of the normal complement of hand tools, such as wrenches, screwdrivers, nutdrivers, etc., in addition to battery powered screwdrivers.

### *Electrical Assembly Equipment*

Electrical assembly equipment includes soldering irons, wire wrapping tools, holding fixtures, and other miscellaneous tools associated with wire bonding and joining. Many of these tools are part of minor equipment issued to operators and used in day-to-day activities.

### *Wire Wrap Equipment*

There are currently five wire wrap machines in the chassis area. The operational area of each machine is provided with tooling attachment points to clamp sub-assemblies during the wiring process. This equipment performs wire wrapping for various device base plates and receives data input via eight-level perforated tape.

Additionally, tooling plates are used to correctly position the I/O connectors for wiring. These plates are unique to each device used in FM & TS programs.

### *Test Equipment (DITMCO)*

DITMCO fixturing consists of cable sets used to interface the tester with the miscellaneous chassis under test. This also permits the continuity testing of a variety of wire wrapped assemblies.

Installation of adapter cables into the chassis for continuity testing is manual and requires high insertion forces. Operators are exposed to the potential for "Carpal Tunnel Syndrome" due to methods employed to seat adapter cards in the chassis under test.

### *Machine Group (External) Equipment*

The machine group includes several pieces of equipment that are used for processing work-in-process from the chassis area. This equipment can generally be described as older (15 years or more) pneumatic and/or manually operated staking and riveting machines.

### *Miscellaneous Equipment*

There are a number of other miscellaneous pieces of equipment that are employed in the chassis area for performing various operations. A general list of these pieces of equipment includes:

<u>Manufacturer</u>	<u>Description</u>
Baron-Blakeslee	Degreaser
Cannon	Pneumatic Crimper
DEC	PC w/ printer
Gardner Denver	Wire Stripper

#### 4.9.2 Transformer Area Equipment

The equipment currently used in the transformer area consists of equipment used for winding, leadsetting, testing, and epoxy and dirty operations.

##### *Winding Equipment*

The transformer/coil fabrication equipment, while of significant age (15-20 years), appears reliably functional. Transformer production volumes are of sufficiently low level resulting in a minimal level of equipment wear. The greatest liability of equipment age is securing repair parts when the inevitable failure does occur.

The winding equipment used in the transformer area can be characterized as electrically driven and controlled with both mechanical and electrical readouts.

This equipment includes:

<u>Manufacturer</u>	<u>Description</u>
Meteor	Bobbin Winder
Levin	Lathe Winder
Honeywell	Hand Winder
George Stevens	Hand Winder
Levin	Lathe Winder
Gorman	Toroid Winder
Leesona	Stick Winder
Leesona	Coil Winder
Gorman	Toroid Winder
Bachi	Bobbin Winder

##### *Leadsetting Equipment*

In addition to the required soldering and insulation stripping equipment such as solder pots, fume hoods, abrasive strippers, etc., the leadsetting area utilizes various clamps and fixtures to position magnetic components during lead preparation and termination operations.

### *Test Equipment*

Equipment utilized for testing consists of several large consoles configured to test the more complex attributes of transformers in addition to various smaller testers used to check winding polarities, turns ratios, shorted turns, etc. Miscellaneous equipment such as oscilloscopes, signal generators, frequency meters as well as meters for measuring voltage, power, and current are employed in testing magnetics. Additionally, much of this same equipment is incorporated into the test consoles.

The variety of manual transformer testers require time-consuming setups and movement of parts from tester to tester depending on parameters measured.

This test consoles include:

<u>Manufacturer</u>	<u>Description</u>
Honeywell	Transformer Test Stations
Honeywell	Magnetic Station

### *Ovens*

The oven equipment is used to cure and/or prep transformer area products for encapsulation, impregnation, and coating. One oven is associated with the test stations for transformer and inductor burn-in. These ovens encompass a large variety which are all manually controlled.

This equipment includes:

<u>Manufacturer</u>	<u>Description</u>
Precision	Ovens
Despatch	Oven
Tenney	Ovens

### *Epoxy, Dirty Room and Miscellaneous Equipment*

The following equipment is used in either the dirty room (in which operations that produce unusual contamination opportunities are performed), epoxy operations, or in one of the transformer winding, leadsetting, or test areas. This equipment includes:

<u>Manufacturer</u>	<u>Description</u>
Honeywell	Vacuum Chambers
Sears	Refrigerator
Silver King	Refrigerator

<u>Manufacturer</u>	<u>Description</u>
Environmental	Cold Box
Hewlett-Packard	Vector Meter
DoAll	Band Saw
Challenge Machine	Paper Cutter
LabConCo	Fume Hood



## **SECTION 5**

### **"TO-BE" PROCESS**

The following section describes the "To-Be" processes that will be in place as a direct result of ITM Project 88. In addition, several areas are described within the FM & TS chassis and transformer environments that, while not directly affected by the improvements incorporated for ITM Project 88, either provide the groundwork for the improvements developed or are tangentially affected by the efforts dedicated to ITM Project 88.

The primary emphasis of ITM Project 88 is on the improvement of material handling systems and equipment as well as the relayout of the FM & TS chassis and transformer areas. Other areas described in this section include:

- Production/Process Flow
- Material Flow
- Information Flow

#### **5.1 "To-Be" Operations Overview**

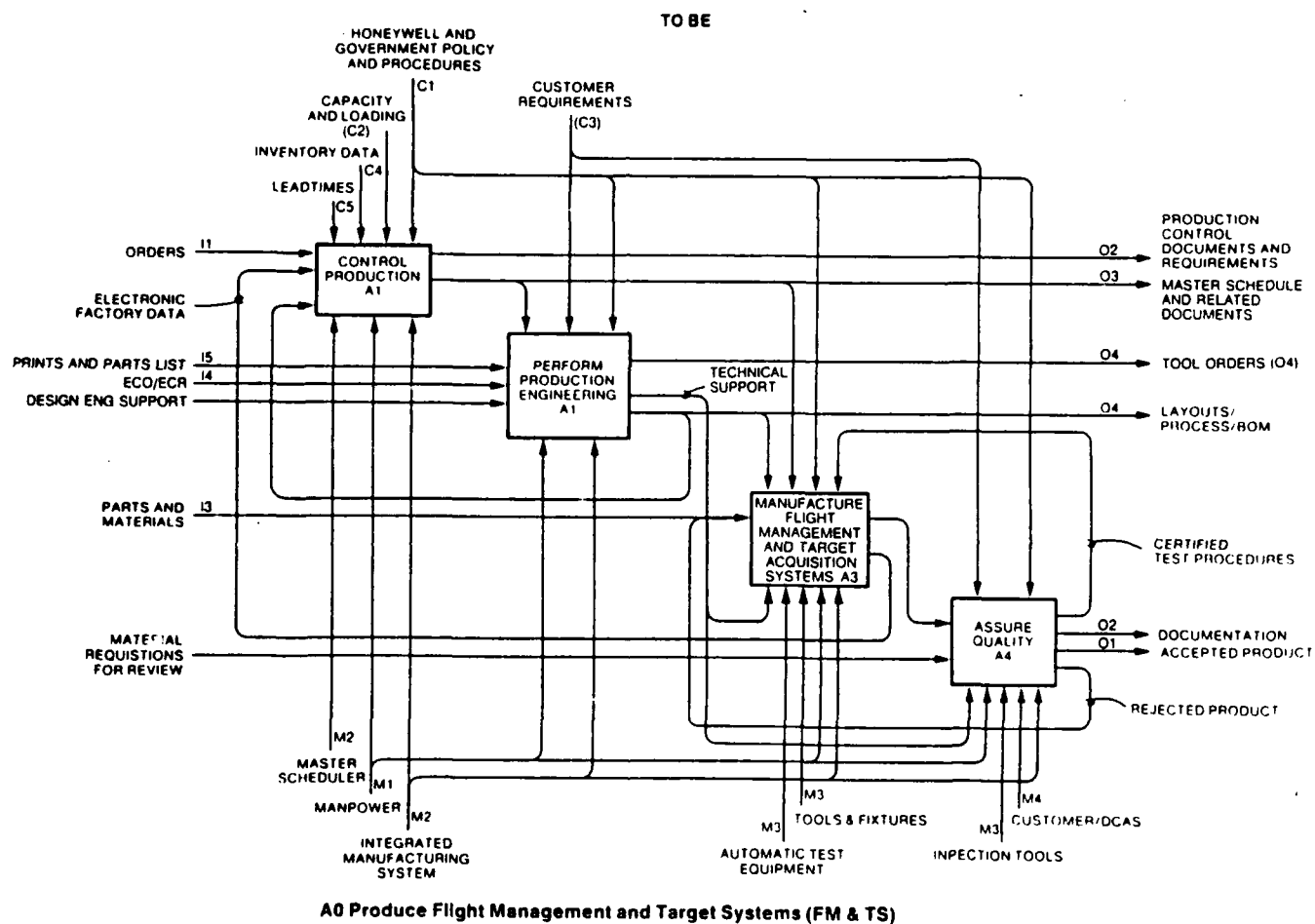
The "To-Be" operations for the chassis and transformer areas include improvements in the layout and material handling methods used in the areas as well as improvements in production, assembly, and test equipment described in the following section. While all improvements are described in general in this section, the emphasis of the following section is upon improvements resulting from relayout activities and material handling efficiencies.

Figure 5.1-1 presents an overview of the "To-Be" processes required to produce FM & TS products.

#### **5.2 FM & TS Area Floor Plans**

The floor plans designed for the chassis and transformer areas were developed using the methodology described in Section 3 of this document. In short, this methodology requires that the manufacturing operations be first divided by hierarchical levels to define the specific areas (transformer and chassis) and their relationship to the other areas within FM & TS (this process is further described in both Sections 4 and 8). These areas were then analyzed to determine the work "cells" that defined the current structure of these areas.

Once the work "cells" were defined, they were then analyzed in respect to the types of workstations that made up each of these "cells". The word cells has been used in quotes here because, in the current structure, the FM & TS layout did not define work cells or clusters in the same manner as described in Section



**Figure 5.1-1 "To-Be" Production Process (FM&TS)**

3 of this document. Once each workstation type was defined, the equipment currently used at each of these workstations was described.

The process for developing a new floor plan necessitated that equipment requirements be developed for the individual types of workstations and that this equipment was specified (new or improved equipment specifications are included later in this section and in Section 9). The process then becomes a "building up" of the areas where equipment requirements define workstation design, workstation/process requirements define the unique work cells or clusters, and work cell requirements then define the overall work area design.

At all points during this process, additional requirements and constraints (such as available floor area, environmental factors, business projections, etc.) were analyzed and modifications were introduced into the design to account for these factors. The following sections describe the final floor plan layout. The iterations that were performed during this process are described in more detail in Section 8. This section is provided primarily to describe the efforts and justifications that were involved in the development of the final floor plan. Figure 5.2-1 depicts the location of the "To-Be" Chassis, Transformer, and Epoxy areas within the overall Honeywell St. Louis Park facility.

#### **5.2.1 Chassis Area Floor Plan**

The resulting floor plan developed for the chassis area is presented in Figure 5.2.1-1 and can be characterized as providing the following features:

- 1) Wide aisles have been included to facilitate the ease of work flow.
- 2) Wire wrap units have been clustered to allow for ease of access for wire wrapping operations and arranged by frequency of use.
- 3) VS/RS storage units are centralized at wire wrap operations to provide storage of wire wrap adapter plates and supplies and at the DITMCO tester for adapter and work-in-process assembly storage.
- 4) Assembly stations are arranged for a smooth flow from operation to operation.
- 5) Spare work bench surfaces are distributed to allow for work load peaks and new product development areas.
- 6) The DITMCO tester is located in a direct path to the main area entry point to provide free access for outside work.
- 7) Wire preparation activities are located in a separate, isolated room.
- 8) Machine Group operations have been incorporated into the area.

Honeywell  
St. Louis Park  
Facility

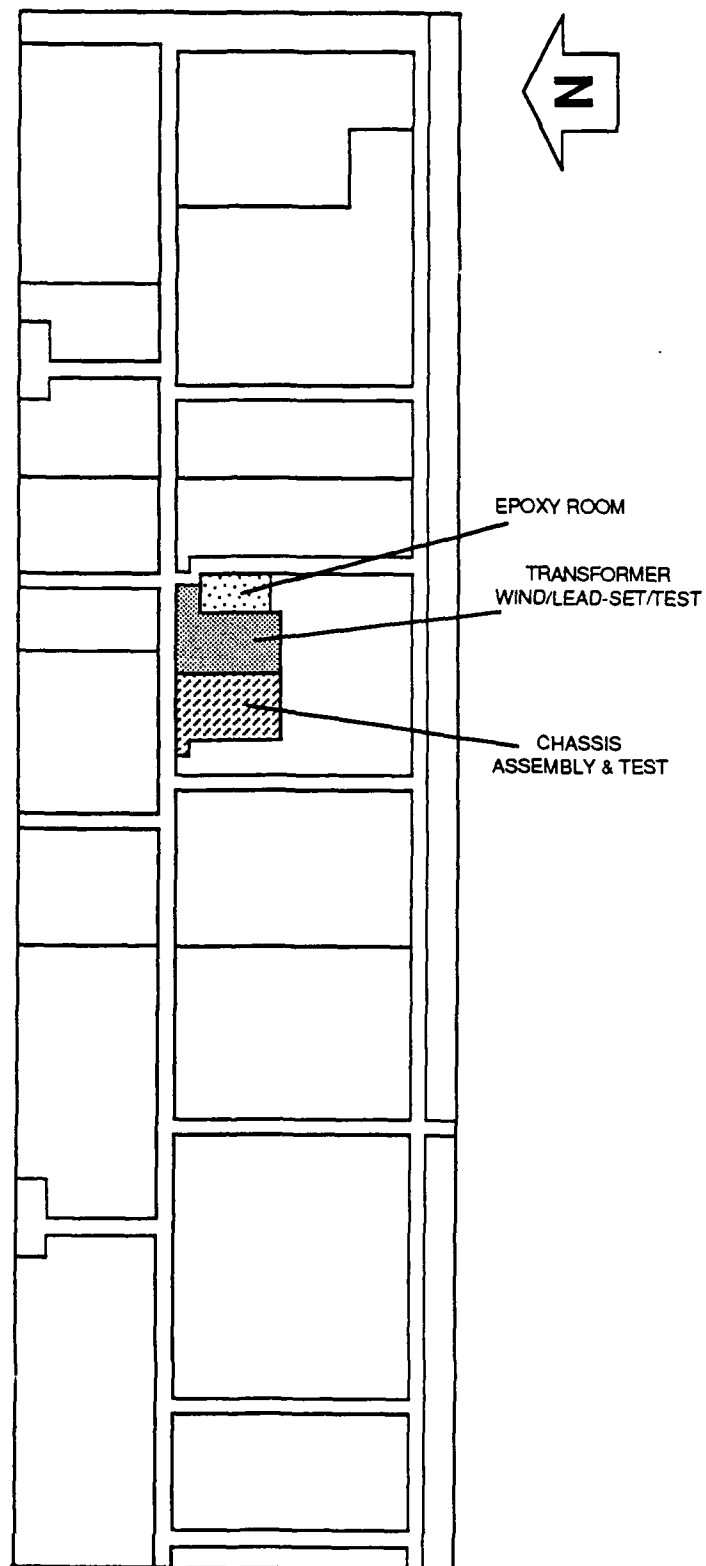


Figure 5.2-1 Chassis & Transformer Areas  
To-Be Location

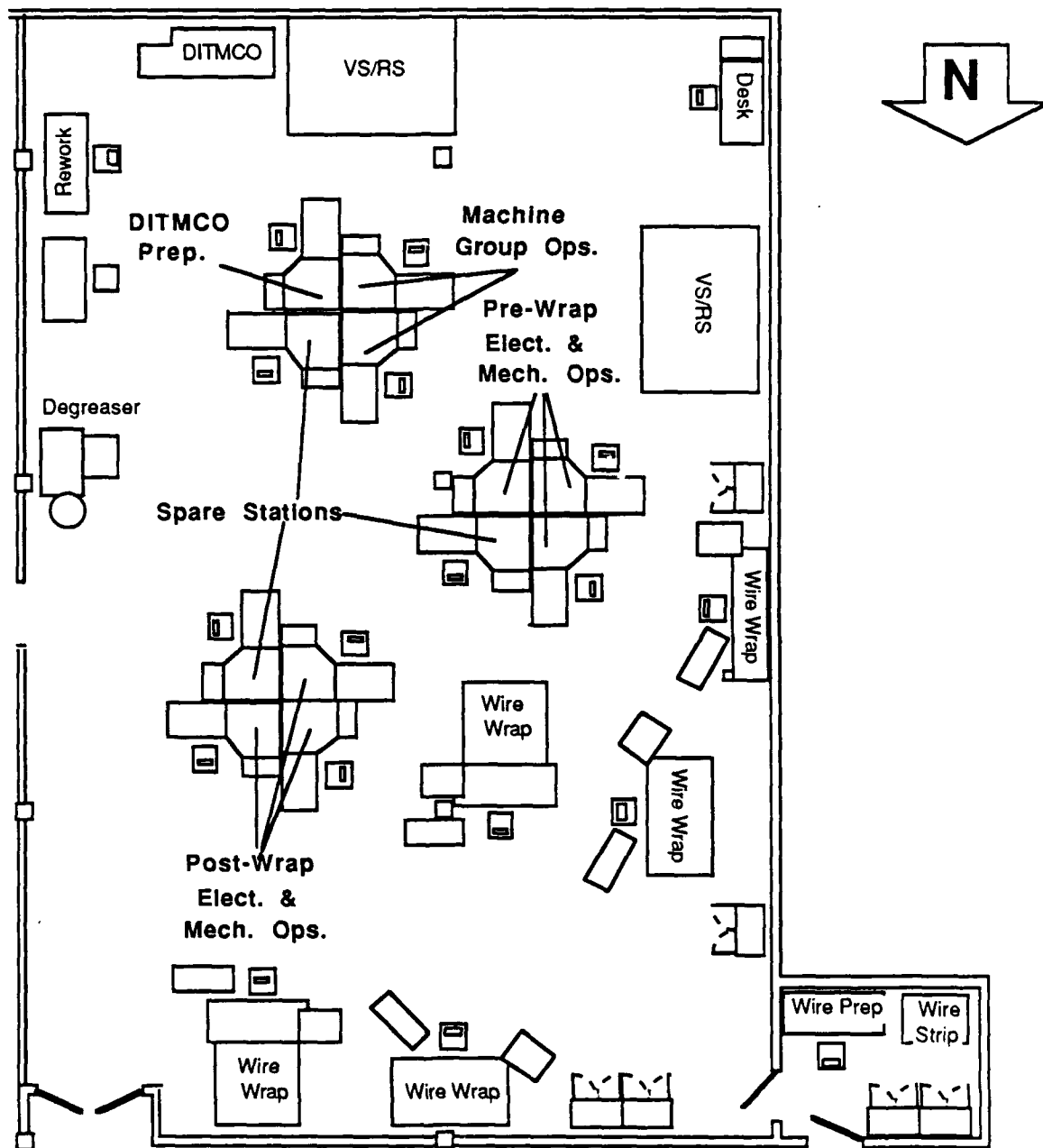


Figure 5.2.1-1 "To-Be" Chassis Area Layout

- 9) Work benches are clustered to provide functional workstation grouping.

The major factors emphasized in the proposed floor plan include a more "free-form" environment with wider spacing, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.

The proposed floor plan provides for an average reduction of flow distance by 34%. While this reduction is not necessarily a significant cost driver for evaluating the improved chassis area arrangement, the non-quantifiable improvements in efficiency, reduction of material movement required by Group Leaders, and several other factors support this improved layout.

### **5.2.2 Transformer Area Floor Plan**

The resulting floor plan developed for the transformer area is presented in Figure 5.2.2-1 and can be characterized as providing the following features:

- 1) Transformer area is generally laid out to provide a smooth flow from wind to leadset and/or test followed by the necessary impregnation and encapsulation operations.
- 2) Layout is configured with more than adequate aisle space so that variations in process requirements from assembly to assembly do not pose significant flow problems.
- 3) Winding area is laid out so that machinery with high utilization is grouped in a centrally located "island".
- 4) One VS/RS unit is positioned in close proximity to the winding area to provide wire and coil-form supplies to the winding cell (this unit could optionally be configured to be restocked from the back, if desired)
- 5) The second VS/RS is located near the leadset operations to provide supplies support and work-in-process storage.
- 6) A third VS/RS is located in the epoxy room for supplies storage.
- 7) The epoxy room is shown as being located outside the current "airlock". Parts are moved to and from this area through a slide up window. (Alternately, if the airlock/clean room environment is not required, an access doorway could be provided at this location).
- 8) A small room is provided for "dirty" operations in the transformer area. Additionally, this room can function as an "airlock" for the transformer area as an alternative to the existing access ways.

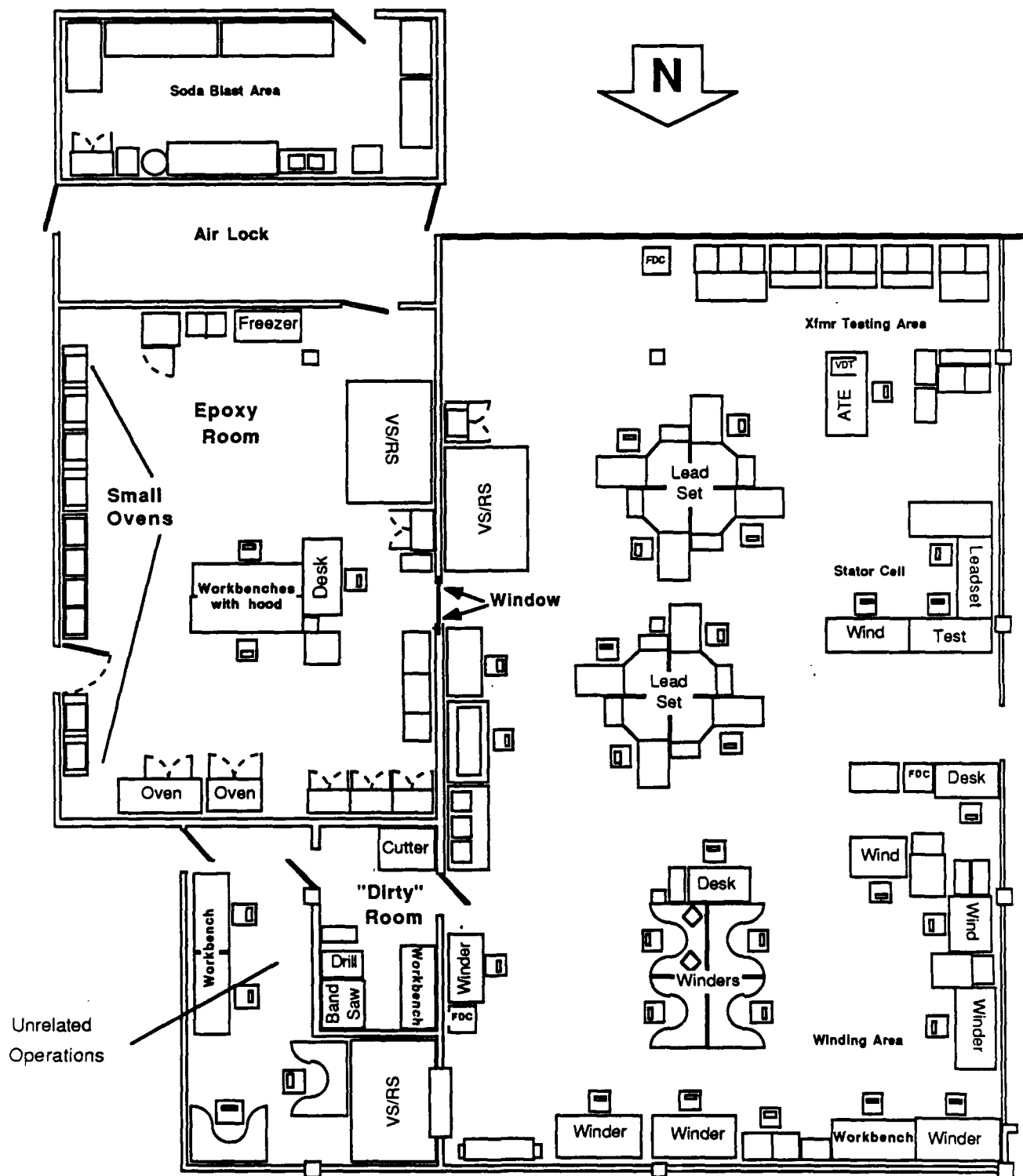


Figure 5.2.2-1 "To-Be" Transformer Area Layout

- 9) Existing soda blast room has been re-oriented to allow an improved layout and placement of the epoxy area.
- 10) Epoxy room has been re-oriented to provide additional aisle space with a centralized bench area. Curing ovens are grouped along the walls toward one end of the room and clustered around the bench "island" so that work can be prep'd and moved back and forth between ovens and work surfaces.
- 11) Provisions have been made to accommodate all existing transformer test equipment as well as the ATE unit specified in this document. Eventually, the use of most of the manual testers can be eliminated when programs and fixtures are developed for the new ATE unit.

The major factors emphasized in the proposed floor plan include more consolidated operations, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.

The proposed floor plan provides for an average reduction of flow distance by 95% (see Section 5.4 for a more detailed description as to how this percentage was developed). While this reduction is not necessarily a significant cost driver for evaluating the improved transformer area arrangement, the non-quantifiable improvements in efficiency and the reduction of material movement required by Group Leaders and stores personnel support this improved layout.

### **5.3 "To-Be" Production/Process Flow**

The "To-Be" production/process flow is presented in the following sections. One of the major improvements in the optimized design of the production/process flow for each of the areas is the development of a straightforward production flow that is aligned with the process flow. Additionally, in the transformer area, the consolidation of the geographically distinct operations will result in significant production flow improvements.

#### **5.3.1 Chassis Area Production/Process Flow**

The chassis area in the "To-Be" configuration integrates the sequential processes necessary to produce a finished for chassis within the various military programs so that duplication of stations is unnecessary to ensure uninterrupted product flow.

Each wire wrap plate passes through a series of stations to and from wire wrap depending on the necessary preparation or post wrap work. Since no program volume is sufficient to fully utilize a given station (except wire wrap), the process orientation allows significant labor consolidation. Similarly, in



chassis build-up, tooling and parts are centralized and material stocking can be concentrated in storage systems (e.g., VS/RS) to save transit, search, and picking times.

### **5.3.2 Transformer Area Production/Process Flow**

A survey of the top eighty percent of transformer assemblies and sub-assemblies produced during 1986 was performed to establish the transport profile for the area and determine the resources required to move these parts through the production process.

The transport between the respective operational areas consumed an estimated 1474 hours during 1986. This is important in two respects. The consolidation of the separate areas could potentially reduce the stockroom allocation to FM & TS. Also, delays in processing and the effective application of FM & TS transformer personnel will be positively impacted as a result of maintaining uninterrupted production flow.

Intra-area movement provides minimal savings. This is a result of the relatively small number of transformer/sub-assembly lots processed. The comparison of flow distances within the "As-Is" and "To-Be" layouts resulted in a five percent transport reduction.

Additionally, the project team believes, and current industry experience bears out, that the combination of consolidating the respective transformer operations and developing ergonomic work cells will result in productivity gains in excess of ten percent per year.

## **5.4 "To-Be" Material Flow**

The improvements in the "To-Be" material flow are presented in the following paragraphs. In general, a number of characteristics can be stated regarding the improvements in both the chassis and transformer areas. The most important improvements in the material handling for both of the areas involves the methods and equipment used for material and fixturing storage.

### **5.4.1 "To-Be" Chassis Area Material Flow**

The chassis area material flow will be significantly improved through the implementation of three major types of material handling and storage devices. These are:

- Vertical Storage and Retrieval Systems (VS/RS)
- Bench-top Rotary Parts Presentation Bins
- Dedicated Material Handling Carts

#### **5.4.1.1 Vertical Storage and Retrieval Systems (VS/RS)**

In the current chassis area configuration, over 1,000 cubic feet is devoted to storage of all types, including fixtures, wire wrap plates, queued material, work-in-process, fasteners, wire, repair parts, etc. In gross numbers, over a third of material currently stored is related to work-in-process, another third is made up of DITMCO fixtures, cables, and other related miscellaneous materials, and the balance is divided between wire wrap materials and supplies.

In the "To-Be" chassis area operations, a majority of all of the material in these work areas will be stored in Vertical Storage and Retrieval Systems (VS/RS). VS/RS units are automated, micro-processor based storage and retrieval systems which occupy small footprints of space. Items are stored in pans which travel following a vertical enclosed loop track. Pans are brought to work counter height via the shortest route. An operator does not have to bend, search, or grow fatigued looking for an item, therefore improving productivity.

These systems will reduce the floor space utilized for storage significantly and consolidate material into specific areas adjacent to the materials' points of use which reduces the material movement travel time. It will also assist group leaders and operators by significantly reducing the time associated with locating materials.

It is proposed that one VS/RS be oriented near the DITMCO tester to supply production parts and store work-in-process. The second VS/RS will be utilized for wire wrap related parts, fixtures, and supplies. Storage of DITMCO cables will be in cabinets until a feasible set-up arrangement can be developed for their storage by some other means.

Another significant improvement associated with the implementation of the VS/RS units is the purchase of a computer-driven material locating system for each of the VS/RS units. While many users require a simple "go to pan" operation, to take full advantage of these units, a storage and retrieval locating system is proposed. This will serve to eliminate excessive time required to search for the appropriate materials and more optimized utilization of the storage devices.

#### **5.4.1.2 Bench-Top Rotary Parts Presentation Bins**

Bench-top rotary parts presentation bins are motor-driven and allow an operator to advance a selected part into view by depressing a remote footswitch or control panel button. One of these bins provides spaces for as many as 120 different small parts such as screws, nuts, resistors, capacitors, connector pins, etc.

By grouping parts unique to various assemblies on different levels, increased efficiencies can be achieved through the elimination of searching for material in remote parts bins. Replenishment is similarly augmented.

#### **5.4.1.3 Dedicated Material Handling Carts**

In the proposed plan, material would be transported throughout the work area on carts with a very limited number of shelves and closeable/lockable doors. The major premise behind this is to only have material on the shop floor that is being worked on and all other materials stored. Since work-in-process storage could potentially occupy approximately 200 cubic feet in the Vertical Storage and Retrieval System, improved material handling disciplines must be established.

The benefit of limiting work-in-process storage to carts (with work-in-process in the VS/RS stored either due to lack of materials to complete the job or as completed sub-assemblies) is that what is actually "in-process" will be readily apparent. The Japanese liken this method to that of draining a pond to make the bottom a smooth surface. As water is taken away, the largest rocks appear first. As each rock (or unnecessarily stored item) is removed, the pond is further drained until all of the rocks are removed.

By not providing unlimited storage areas, problems related to timely delivery of kitted parts, etc. will surface and be more effectively dealt with.

#### **5.4.2 "To-Be" Transformer Area Material Flow**

The transformer area material flow will be significantly improved through the implementation of Vertical Storage and Retrieval Systems. Currently, the storage of all materials in the transformer area is in a variety of cabinets distributed throughout operational areas. The greatest amount of cabinet space is assigned to store wire and other winding related materials. In other areas, there are seventeen large cabinets and over twenty "under bench top" shelves used to store assembly, leadsetting, and epoxy materials. In total, there are forty-eight individual storage locations totaling over 940 cubic feet.

By establishing three VS/RS units, one each in winding, leadset, and epoxy, this storage space can be centralized for material presently spread around the areas. Furthermore, easier storage and retrieval will be made possible via the automatic locator system described in the previous "To-Be" Chassis Area Material Flow section.

The VS/RS units will increase floor space utilization by concentrating a greater amount of cubic storage in one area through the use of three additional feet in height. By bringing material to a usable height for placement/retrieval, spaces which are normally wasted in cabinets (near the floor or above an operator's head) are reclaimed for use. A ten foot high VS/RS can make available 350 cubic feet of storage in a space that tall cabinets can only provide 190 cubic feet, an increase of 84%. Additionally, travel distance with a VS/RS is cut to one-quarter to access the equivalent volume.

The proposed integrated and consolidated transformer area will contain three VS/RS units. These will serve the main activity areas of wind, leadset, and epoxy. This will provide supplies closely coupled to the point of use. Also, since winding takes up all of one VS/RS unit, the proximity of the second unit will permit any excess storage to be placed in the leadset VS/RS.

An integral part of the storage concept revision in the transformer area is the introduction of workstations which augment product flow and enhance material consolidation. By utilizing a workstation which eliminates "hidden" material storage and allows an operator to concentrate on a specific task, both objectives are satisfied.

### **5.5 "To-Be" Information Flow**

The most significant improvements in the chassis and transformer area information flow will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. While on a conceptual level this system performs all of the same processes as the GAPOS system, the increase in functionality is significant. Because the two systems are similar in the types of functions they will be performing and the final definition of the system has yet to be implemented, the focus of this section will be primarily on the introduction of the Factory Data Collection system and the improvements outlined in this report that can be even further upgraded due to their selection for interfacing with a work center controller.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part being built. It is envisioned that in the future, the FDC system will be expanded to provide location tracking of work-in-process as well.

It is envisioned that at some point in the future that the Vertical Storage and Retrieval Locator System will be interfaced to HMS/BOS, either directly (which is not recommended) or through another system such as the Factory Data Collection System. This would provide a more integrated material tracking system.

One other program which is currently under evaluation for Honeywell's MAVD is the introduction of a "factoryvision" system (ITM Project 32) which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with a work center controller would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

## **5.6 "To-Be" Equipment**

The following subsections list the equipment proposed for implementation in the FM & TS chassis and transformer areas. This equipment significantly improves the operations in these areas and provides for the operations of these areas on a higher level of automation with, in some cases, the upward compatibility to an advanced work center controller being considered for future implementation.

### **5.6.1 Chassis Area Equipment Improvements/Upgrades**

There are a number of equipment improvements or upgrades that are presented in the "To-Be" operations in the chassis area that affect the overall work area design. This equipment includes:

- Vertical Storage and Retrieval Units
- Rotary Parts Presentation Equipment
- Material Handling Carts

### **5.6.2 Transformer Area Equipment Improvements/Upgrades**

There are a number of equipment improvements or upgrades that are presented in the "To-Be" operations in the transformer area that affect the work area design. These improvements include:

- Modular, ergonomic workstations
- Vertical Storage and Retrieval Units

## SECTION 6

### PROJECT ASSUMPTIONS

ITM Project 88 has proceeded with the following assumptions as fundamental guidelines. Project implementation could be impacted and schedules affected if alternative approaches or significant deviations to plan are executed.

- Capital funds will be available for equipment purchases during fiscal year 1988.
- Sufficient manpower to implement proposed changes will be allocated to ITM Project 88.
- FM & TS Production Engineering will coordinate implementation efforts.
- Each unique workstation will be configured and pilot testing will be completed prior to commencement of full scale production. This activity will occur within the respective area utilizing production operators.
- Implementation will not be considered finalized until designated equipment is in place as depicted in the ITM Project 88 plan.
- As much as practical, software packages procured as part of the project implementation will be standard, off-the-shelf products so as to avoid on-going maintenance associated with customized packages.
- For the project duration, the transformer build schedule is assumed to be flat while the chassis build is tied to revenue growth within FM & TS.

## SECTION 7

### GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The term Group Technology has been alternately used to describe either of the following:

- 1) a process of codifying parts in a computer database in order to group similar parts or,
- 2) the organization of product families into cells in order to eliminate the duplication of resources.

The first definition of Group Technology was developed during the 1970's for the standardization of production materials and is used in a number of ways in the design and manufacture of a wide variety of products. The major impetus for this came through the use of more powerful and sophisticated computer systems and integrated CAD design software. This technique was not viewed as particularly critical to the development of the design and equipment requirements for ITM Project 88.

The second definition presented above is a more recent view of Group Technology. This method has been adapted from the Japanese and provides a more global view of integrating manufacturing processes and streamlining production operations.

The grouping of production operations was achieved by developing large scale matrices which correlated the Honeywell part number with the operations and the standard hours required to perform these operations. These correlation matrices provided important information for grouping similar processes at workstations, defining the equipment required at each specific type of workstation as well as the actual number of workstations required for each of these groupings of operations.

The steps for developing this matrix were:

- 1) All part numbers of assemblies and sub-assemblies were listed along the "y" axis of the matrix.
- 2) Production layouts provided the operations descriptions (which are in the process of standardization and codifying) for each operation for the production of a sub-assembly or assembly. These operations descriptions were listed along the "x" axis of the matrix.
- 3) At each intersection in the matrix of a part number and an operation description, the standard hours for an operation for that part number were entered.

- 4) After the data was entered into the matrix, each individual production operation was analyzed for grouping at a specific type of workstation dependent upon the processes performed.
- 5) Similar processes or processes requiring the same type of tooling and equipment were grouped together.
- 6) The matrix was then condensed to define a set number of types of workstations that could facilitate the grouped operations.
- 7) On separate versions of the matrix, production totals (box and spares counts) were entered for the years 1986 and 1987. These were then multiplied for each part number and each operation column was totaled.
- 8) These standards were then verified for 1986 using the Foreman's Cost Report (for total hours in each operational area) as a check against the completeness of the matrix.
- 9) Business volume projections were established for the operational area (chassis, transformer) and standard hours were projected for ten years using an established percentage growth for the FM & TS operations.
- 10) Actual hours for each type of workstation were established using cost variance ratios established by FM & TS Cost Accounting department.
- 11) Actual number of workstations was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours/year/employee allows for 80 hours vacation, 80 hours holiday, 120 hours for lost time (sick, jury, etc.).
- 12) This established the number and type of workstations required for all current programs for the next ten years and provides a methodology for establishing the number and type of workstations required as newer programs are phased in.

Once all of the workstations were designed using the procedures outlined above, the groupings of the workstations were laid out based upon the process flow to provide optimized routings for the majority (approximately 80%) of the product that will be built in the work area. In addition, the accessibility of resources was analyzed in relation to the work cell designs as well as the physical characteristics of the products assembled.

Following the development of the work cells, these were then laid out for optimum routing between each cell. Once the work area was designed, the material handling and storage requirements were developed to facilitate the process flow between cells.



## **SECTION 8**

### **PRELIMINARY/FINAL DESIGN AND FINDINGS**

The following section describes the process of preliminary findings and design iterations as well as the Final Design that will be in place as a direct result of ITM Project 88 and the final design findings that led up to it. In addition, several areas are described within the FM & TS chassis and transformer environments that, while not directly affected by the improvements incorporated for ITM Project 88, either provide the groundwork for the improvements developed or are tangentially affected by the efforts dedicated to ITM Project 88.

The primary emphasis of ITM Project 88 is on the improvement of material handling systems and equipment as well as the relayout of the FM & TS chassis and transformer areas. Other areas described in this section include:

- Production/Process Flow
- Material Flow
- Information Flow

#### **8.1 "To-Be" Operations Overview**

The approach to the development of the final design of the "To-Be" factory has been described in Section 3 "Technical Approach" of this document. In addition, in describing the "To-Be" factory in Section 5, the refined methods for arriving at the "To-Be" design are included as part of the justification and description of that design.

#### **8.2 FM & TS Area Floor Plans**

The preliminary floor plan design began with an evaluation of three factors:

- Product volume
- Processes employed
- Product flows

##### *Product Volume*

The product volumes were derived from 1986 chassis and transformer area completion records. Where applicable, model (or program) identification was maintained. In the chassis area this would prove to be useful in minimizing transit distances for the higher volume programs. In the transformer area, a similar process would sequence the magnetics with higher annual volumes.

It was also necessary to validate the matrix data with product quantities and standard-to-actual ratios. This effort would provide a benchmark for determining headcount by comparison of 1986 totals obtained from different sources. Additionally, marketing data provided a projection of future years' expectations and an estimate of space required to accommodate growth.

The aforementioned combination yielded a projected headcount figure over the project duration and identification of gross workstation space.

### *Processes Employed*

The matrix (referred to above) also permitted a grouping of the same or similar operations. These were then reviewed to determine combinations of tools and/or skills which were capable of being combined.

As an example, the result in the chassis area was the establishment of process oriented stations, through which all chassis assemblies and sub-assemblies pass, as dictated by the processing each requires.

In the transformer area, similar operations, though performed on different machines, were clustered. This approach ultimately conserves the manpower resource where volumes are insufficient to require full-time attention to one product or assembly.

### *Product Flows*

A major goal of the ITM program in FM&TS in general was the consolidation of production areas. In the chassis and transformer areas, significant travel is dictated by the physical location of areas within the St. Louis Park facility as well as the internal layout of those areas. The preliminary design addressed those flows and resulted in significantly altered floor layouts.

### *Design Formulation*

The combination of the previously mentioned volume, processes, and flows resulted in a preliminary plan for the chassis area which essentially had a "U-shaped" flow. Material entered and was successively processed in a semi-circular/counterclockwise fashion. This resulted in an average flow distance reduction of 53% over the "As-Is" configuration. The design was also reviewed with alternative workstation arrangements to provide personnel with various work group options and inter-relationships.

Similarly, the transformer flow was centered around process steps, but there, however, substantial efficiencies were obtained by the integration of wind, leadset, epoxy, and test in one area. Most significant is the ability to direct all transformer activities in one place and optimize personnel resources while minimizing time lost traveling from area to area.

### 8.2.1 Chassis Area Floor Plan

The chassis area floor plan development required that production layouts for all products currently built within the area in 1986 and projected production for 1987 be analyzed. These layouts provided the initial data for establishing standard hours per operation per part number. This data was then used to develop a group technology analysis matrix. Data regarding operations descriptions was defined along the x-axis, part numbers of assemblies and sub-assemblies were listed along the y-axis, and standard hours were entered at the appropriate part number/operation intersection.

Production totals were entered for each of the part numbers in the matrix for 1986 production. A second matrix was used to enter projected production totals for 1987. A calculation was then made by multiplying the production totals by the operation standard hours for each of the part numbers which resulted in a second matrix physically as large as the first one but now representing total standard hours for each unique operation per part number.

Production layouts were subsequently referred to assist in grouping operations that were or could be performed at a specific type of workstation (these groupings are defined in detail in Figure 8.2.1-1). The groupings were then reviewed by personnel within the chassis group for accuracy. The matrices were then consolidated into eight major categories, which were:

- Machine Group
- Pre Wire Mechanical
- Pre Wire Electrical
- Wire Wrap
- Post Wire Mechanical
- Post Wire Electrical
- DITMCO
- Miscellaneous Operations

The next consolidation of the matrix involved grouping all of the part numbers into their respective programs. The numbers calculated for the 1986 consolidated matrix were then verified using the Foreman's Cost Report which lists the total standard hours expended in the chassis area.

Business volume projections were then established for the chassis area in conjunction with Honeywell's Costing and Forecasting groups. These projections were then analyzed to determine the percentage growth for Flight Management as well as Targeting Systems. This percentage growth was then applied to the figures calculated as the 1986 baseline standard hours to determine the standard hours required for production over a ten year period.

The Actual Hours were established using cost variance ratios developed by the FM & TS Cost Accounting department.

**Machine Group**

Stake Clinch Nuts  
 Rivet  
 Press Locking Nuts  
 Key Connectors  
 Install Pins  
 Flare Nuts  
 Key W/W Panel  
 Install Fasteners  
 Install Card Guides  
 Install Inserts  
 Dimple Cover  
 Install Vent Screens  
 Form Counter Sink

**Pre Wire Mechanical**

Assemble Front  
 Load J\* w/ conn assm  
 Load conn & baseplate to fixture  
 Add buss bars to W/W plate

**Pre Wire Electrical**

Load Connectors  
 Crimp contacts  
 Assm hand wires to front panel  
 Hand wire baseplate  
 Insert contacts

**DITMCO**

DITMCO Test

**Inspection**

Visual inspection  
 Machine visual

**Post Wire Mechanical**

Remove W/W assy from fixture  
 Assm W/W assy to chassis  
 Assm rear panel  
 Button-up chassis  
 Assm chassis  
 Install screws  
 Assm switches  
 Rubber pads to cover  
 Assm handle to front panel  
 Attach mounting plates to front panel  
 Bond filter to housing  
 Assm filter assy and ETI  
 Assm bulkhd and brkt assy to chassis  
 Assm parts to rear panel of chassis  
 Assm baseplate and conn to chassis  
 Assm gyro and accelerometer  
 Assm front panel to chas w/ tool brkts  
 Assm divider  
 Assm alignment guide  
 Assm gasket  
 Modify conn  
 Cement gaskets  
 Apply decal  
 Assm elbows to transducers  
 Assm transducers  
 Assm rubber seal  
 Assm parts to bracket  
 Cement  
 Create bead assy  
 Mechanical assy  
 Lock gear, set torque  
 Assm covers over transistor  
 Assm stiffeners and therm assy  
 Assm sidewalls  
 Assm clevis bolt  
 Reform card guides  
 Install springs  
 Assm tubing  
 Assm rubber channels  
 Trim channel  
 Assm cover to cntrl

**Post Wire Electrical**

Assm diode  
 Assm pot, res, jumper  
 Assm amph conn to coax  
 Finish cable  
 Cut & strip coax  
 Assm pass-xstr-assy  
 Attach wires  
 Assm pins to base  
 Assm xformer to base  
 Assm xformer and filter  
 Assm wires to filter  
 Solder  
 Route hand wires  
 Assm ribbon cable  
 Complete wiring front  
 Assm harness  
 Connect leads  
 Wiring cap bracket  
 Twist leads  
 Fill solder cups  
 Pre-wire conns.  
 Tin wire  
 Assm light sw. and wire

**Miscellaneous**

Stamp ID#  
 Mask, primer, paint  
 Remove mask  
 Clean, mask, coat  
 Remove from cure  
 Functional test  
 Silkscreen  
 Strain connections  
 Potting  
 Remove mold and ship  
 Assm semicons  
 Touch up paint  
 Assm cont illum  
 Debug test  
 Install Burn-in  
 Remove burn-in  
 Post burn-in test  
 Final ATP  
 Vibration

Figure 8.2.1-1 Chassis Area Operations Grouping

The actual number of each type of workstation was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours per year allows for 80 hours vacation, 80 hours holiday, 120 hours for lost time (sick, jury, etc.).

After the initial effort to establish the number of workstations required and the characterization of the operations to be performed at the workstations, a number of assumptions and criteria were established and weighted as to importance for developing the chassis area floor plan with respect to work bench surfaces. These included:

- 1) The assumption that the work area would be designed to accommodate all of the work projected during a one shift operation.
- 2) Specific areas would be provided to accommodate work load peaks as well as expansion for new programs and processes.
- 3) Floor space utilization would be minimized so that the footprint of the overall chassis area would be flexible enough for an implementation in a joint area defined to house both chassis and transformer operations.
- 4) Work cells or clusters would be developed to provide a more organized area and more direct process flow. The characteristics of these would be that:
  - a) Cells were developed for specific processes (i.e., machine group, pre wire wrap mechanical, etc.)
  - b) Activities would be clustered to provide advantages of group technology related to similar parts and operations
  - c) Orientations would be developed that permit multiple operations per cell (i.e., riveting/staking and mechanical assembly)
- 5) Standardized modular work benches would be defined to increase the flexibility of rearranging operations.
- 6) Cellular arrangements would be developed taking into account the latest developments in electronics manufacturing ergonomic studies while providing economical utilities (electrical, air, vacuum) installation.
- 7) Areas would be designed which provided for the ability to easily monitor all of the operations in the chassis work center.

After the development of the assumptions and criteria, detailed production flows (such as that shown in Figure 8.2.1-2) were analyzed and used as input to the overall chassis area layout. This analysis focused on the chassis production rates (which was described utilizing pareto diagrams) that represented the highest volume programs so that transport savings would be maximized. This allowed optimization of all work bench surfaces plus additional equipment (wire wrap, etc.).- The assumptions and criteria developed as a result of the production flow analysis included:

- 1) The placement of the DITMCO tester near or in a direct path to an entrance way for ease of accessibility by outside organizations that utilize its unique test abilities.
- 2) Wire wrap equipment location was based upon the frequency of use of the equipment, which is characterized as:

a)	Gardner-Denver:	3 shifts
b)	Synergistic:	3 shifts
c)	Synergistic:	2 shifts
d)	Synergistic:	1 shift
e)	Synergistic:	As required
- 3) Wire cutting and stripping equipment was isolated to decrease the environmental impact of this equipment.
- 4) Cells and other equipment were located to minimize "backtracking" or counterflow in the production process.
- 5) The concentration of the overall work area provided that even though flow distances were minimized, a sufficient area for expansion was provided to accommodate a three to five year time span.

Storage and material handling equipment requirements were developed to meet the needs of production for the next three to five years as well. Storage mechanisms (such as VS/RS) were based upon the volume of stored material and its proximity to the point of use. Briefly, one VS/RS was defined as adequate for DITMCO related equipment and a second unit was dedicated to storage of wire wrap plates, various sub-assemblies, materials, and work-in-process waiting for short parts.

Movable cart storage was determined to be the most effective means of transporting work-in-process and limiting work-in-process storage. This was primarily due to the low volume of production in the chassis area and the relatively small area footprint occupied by the chassis area.

Possible locations for the placement of the chassis area were then reviewed and evaluated for optimum placement of that activity within the total FM & TS production operation. Initially (as shown in Figure 8.2.1-3) it was



Version 1

- 1) Locates Ovens in Common Structure Against Outside Wall.
- 2) Locate Chassis & Wire Wrap Near Main Access to Eliminate Through Traffic Caused by Outside Work.
- 3) Locates FAST Line Between IHADSS and Card & Device for Convenient Access to Major Areas Served.

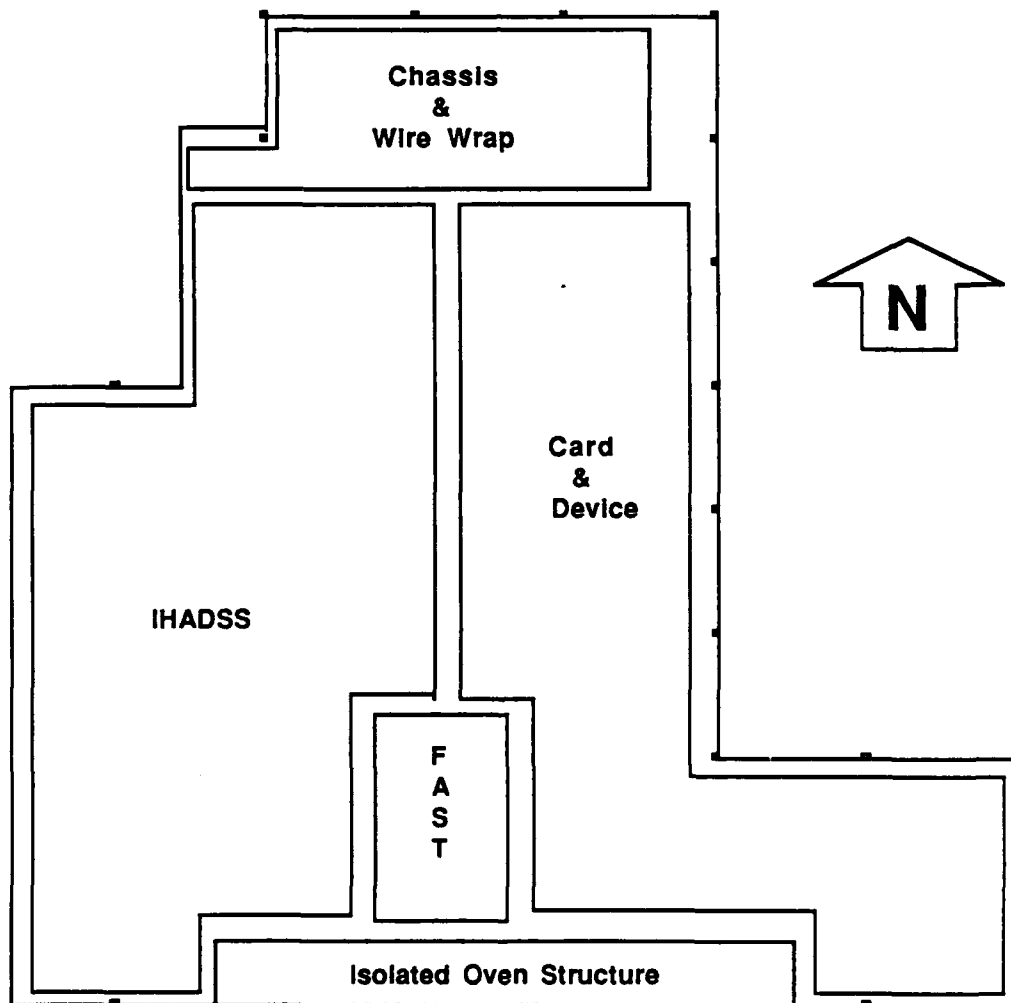


Figure 8.2.1-3 Future FM&TS - Initial Area Layout



determined to group the chassis area with the card and device area as well as the targeting area to facilitate a continuous production flow. One of the area specific designs developed at this time is presented in Figure 8.2.1-4.

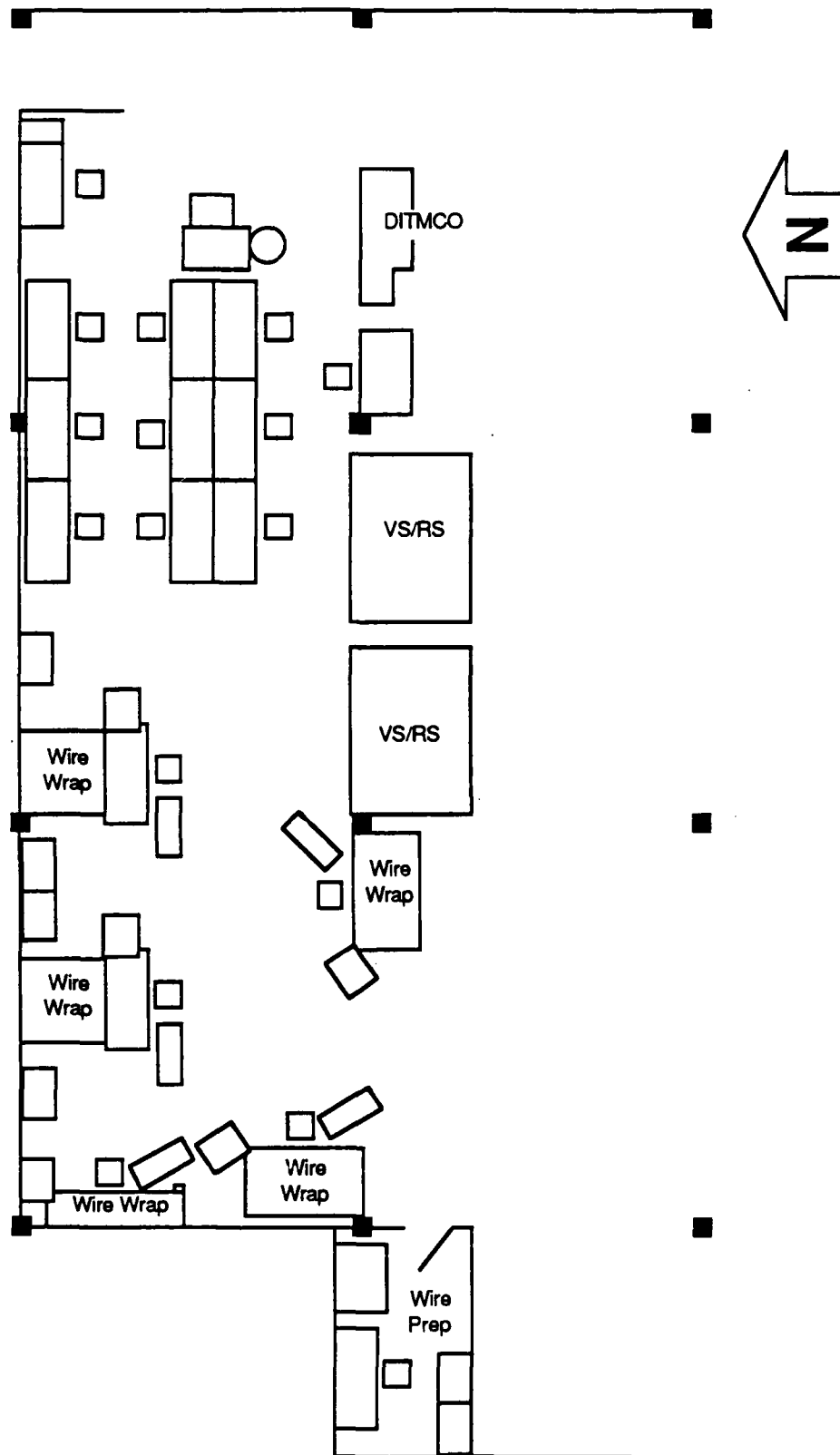
However, additional program development, the requirement that ATE Central be located near the Card and Device testing area, and other factors mandated that the chassis area be located in an area adjacent to the new transformer area.

While this location for the chassis area does not necessarily provide a direct process flow to other areas, the operations performed in the chassis area are unique and separate from all other areas and therefore do not require that it be included as a direct feed to the other areas but rather one of several supplier organizations within Honeywell (such as stores and the card build group).

The resulting floor plan for the chassis area is presented in Figure 8.2.1-5 and can be characterized as providing the following features:

- 1) Wide aisles have been included to facilitate the ease of work flow.
- 2) Wire wrap units have been clustered to allow for ease of access for wire wrapping operations and arranged by frequency of use.
- 3) VS/RS storage units are centralized at wire wrap operations to provide storage of wire wrap adapter plates and supplies and at the DITMCO tester for adapter and work-in-process assembly storage.
- 4) Assembly stations are arranged for a smooth flow from operation to operation.
- 5) Spare work bench surfaces are distributed to allow for work load peaks and new product development areas.
- 6) The DITMCO tester is located in a direct path to the main area entry point to provide free access for outside work.
- 7) Wire preparation activities are located in a separate, isolated room.
- 8) Machine Group operations have been incorporated into the area.
- 9) Work benches are clustered to provide functional workstation grouping.

The major factors emphasized in the proposed floor plan include a more "free-form" environment with wider spacing, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.



**Figure 8.2.1-4 Initial Chassis Area Design**

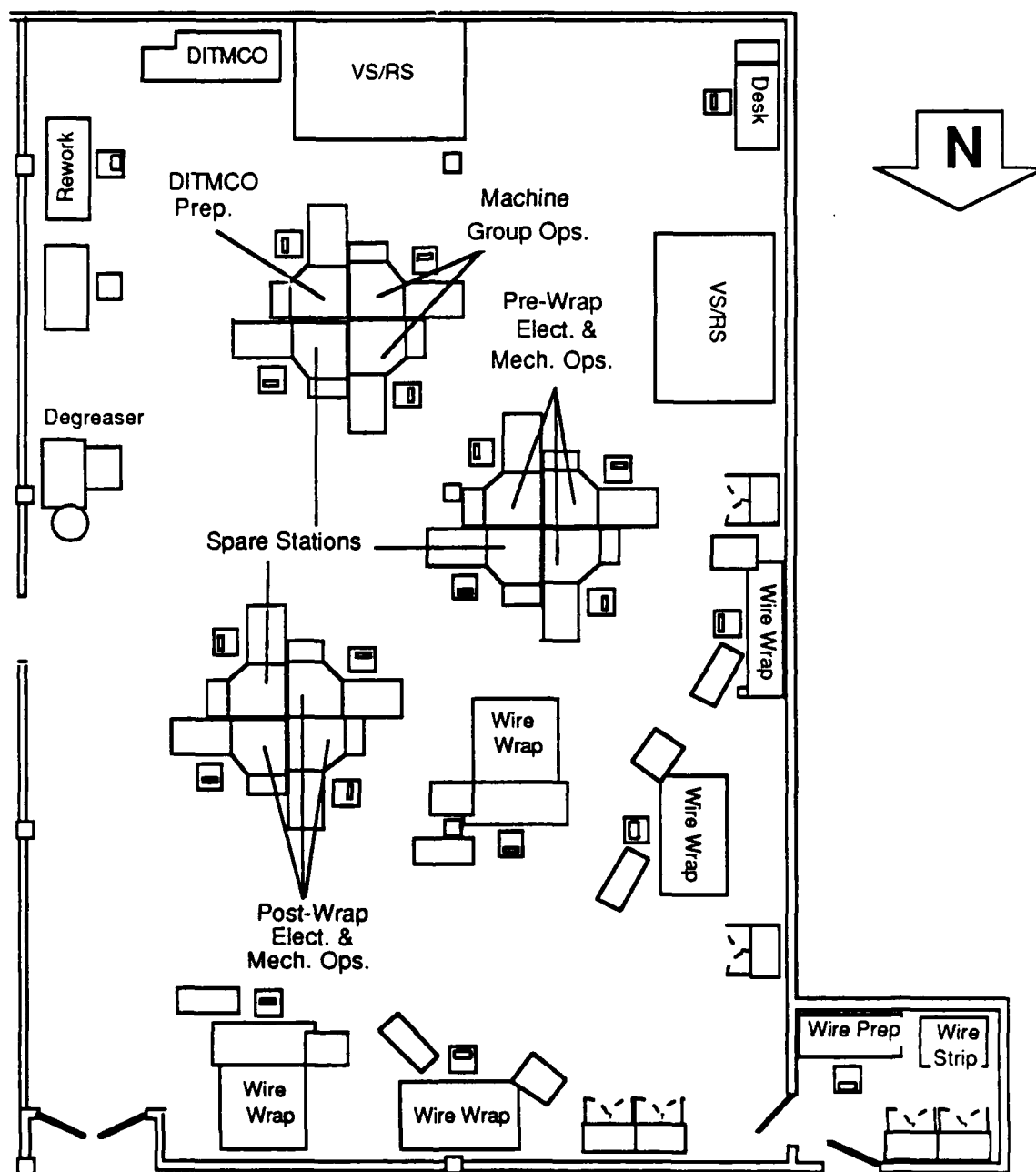


Figure 8.2.1-5 "To-Be" Chassis Area Layout

The proposed floor plan provides for an average reduction of flow distance by 34%. While this reduction is not necessarily a significant cost driver for evaluating the improved chassis area arrangement, the non-quantifiable improvements in efficiency, reduction of material movement required by Group Leaders, and several other factors support this improved layout.

### **8.2.2 Transformer Area Floor Plan**

The transformer area floor plan development required that production layouts for all products currently built within the area in 1986 and projected production for 1987 be analyzed. These layouts provided the initial data for establishing standard hours per operation per part number. This data was then used to develop a group technology analysis matrix. Data regarding operations descriptions was defined along the x-axis, part numbers of assemblies and sub-assemblies were listed along the y-axis, and standard hours were entered at the appropriate part number/operation intersection.

Production totals were entered for each of the part numbers in the matrix for 1986 production. A second matrix was used to enter projected production totals for 1987. A calculation was then made by multiplying the production totals by the operation standard hours for each of the part numbers which resulted in a second matrix physically as large as the first one but now representing total standard hours for each unique operation per part number.

Production layouts were subsequently referenced to assist in grouping operations that were or could be performed at a specific type of workstation. The groupings were then reviewed by personnel within the transformer group for accuracy. The matrices were then consolidated into five major categories, which were:

- Machine Group
- Winding
- Leadsetting
- Epoxy operations
- Test

The next consolidation of the matrix involved adding up all of the part numbers for a production total of all transformers manufactured by FM & TS.

Business volume projections were then established for the transformer area in conjunction with Honeywell's Costing and Forecasting groups. The numbers calculated for the 1986 consolidated matrix were then verified using the Foreman's Cost Report which lists the total standard hours earned in the transformer area.

These projections were then analyzed to determine the percentage growth for Flight Management as well as Targeting Systems. However, as a result of meetings with Honeywell's Costing and Forecasting groups, it was

determined that the growth for the transformer area should be considered as flat since transformer production is primarily devoted to on-going program volumes and the development of prototypes for new products.

The actual hours were established using cost variance ratios developed by the FM & TS Cost Accounting department.

The actual number of each type of workstation (based upon headcount) was established by dividing actual hours per type of workstation by 1800 hours. The assumption of 1800 hours per year allows for 80 hours vacation, 80 hours holiday, 120 hours for lost time (sick, jury, etc.).

After the initial effort to establish the number of workstations required and the characterization of the operations to be performed at the workstations, a number of assumptions and criteria were established and weighted as to importance for developing the transformer area floor plan with respect to work bench surfaces. These included:

- 1) The assumption that the work area would be designed to accommodate all of the work projected during a one shift operation.
- 2) Specific areas would be provided to accommodate work load peaks as well as expansion for new prototypes and production.
- 3) Floor space utilization would be minimized so that the footprint of the overall transformer area would be flexible enough for an implementation in a joint area defined to house both transformer and chassis operations.
- 4) Work cells or clusters would be developed to provide a more organized area and more direct process flow. The characteristics of these would be that:
  - a) Cells were developed for specific processes (i.e., winding, leadset, stator, test, etc.)
  - b) Orientations would be developed that permit multiple operations per cell (i.e., winding, leadset, test)
- 5) Standardized modular work benches would be defined to increase the flexibility of rearranging operations.
- 6) Cellular arrangements would be developed taking into account the latest developments in electronics manufacturing ergonomic studies and accommodate economic utilities installation.
- 7) Areas would be designed which provided for the ability to easily monitor all of the operations in the transformer work center.

After the development of the assumptions and criteria, detailed production flows (summarized in Figure 8.2.2-1) were analyzed and used as input to the overall transformer area layout. This analysis focused on the transformer production volume (which was described utilizing pareto diagrams) that represented the highest volume transformers so that transport savings would be maximized. This allowed optimization of all work bench surfaces plus additional equipment (winders, etc.). The assumptions and criteria developed as a result of the production flow analysis included:

- 1) Clustering of winding equipment associated with higher production volumes.
- 2) Establishment of leadset clusters to concentrate the use of common equipment.
- 3) Incorporation of convenience factors in areas involving multiple transport moves between work surfaces and specialized process points (e.g., Epoxy room).
- 4) Consolidation of the overall work area which, while minimizing flow distance, provides sufficient area for expansion in the following three to five year time span.

Storage and material handling equipment requirements were developed to meet the needs of production for the next three to five years as well. Storage mechanisms (such as VS/RS) were based upon the volume of stored material and its proximity to the point of use. Briefly, one VS/RS was defined as adequate for wire reels used in winding and a second unit was dedicated to storage of leadsetting tools and work-in-process, and a third unit was defined for the storage of epoxy room supplies.

Movable cart storage or carried totes were determined to be the most effective means of transporting work-in-process and limiting work-in-process storage. This was primarily due to the low volume of production in the transformer area and the relatively small footprint occupied by this area.

Possible locations for the placement of the transformer area were then reviewed and evaluated for optimum placement of that activity within the total FM & TS production operation. An area was defined by the Honeywell Facilities Planning organization that was adequately sized to accommodate the transformer operations as designed.

The resulting floor plan developed for the transformer area is presented in Figure 8.2.2-2 and can be characterized as providing the following features:

- 1) Transformer area is generally laid out to provide a smooth flow from wind to leadset and/or test followed by the necessary impregnation and encapsulation operations.

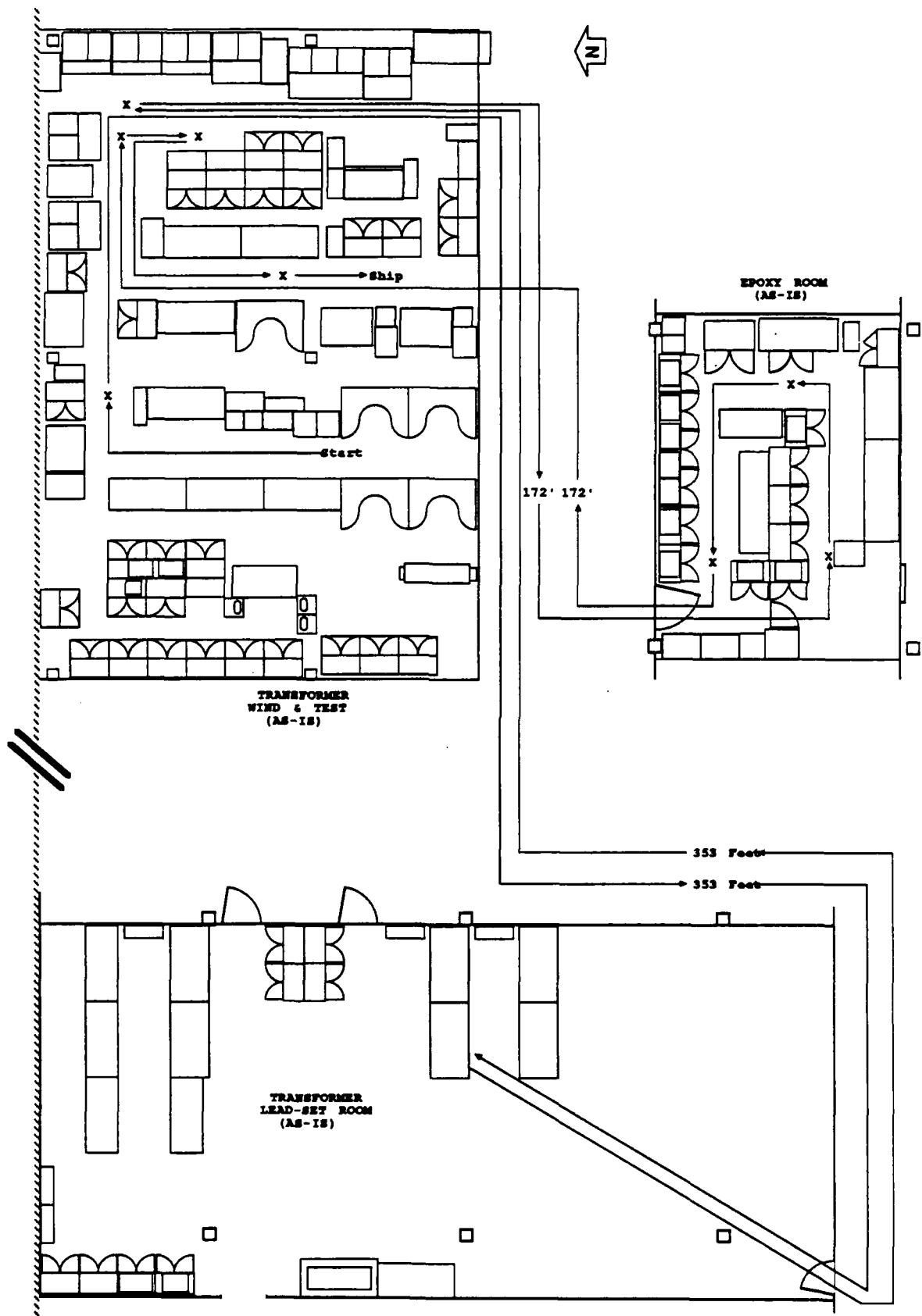


Figure 8.2.2-1 Typical Transformer Production Flow

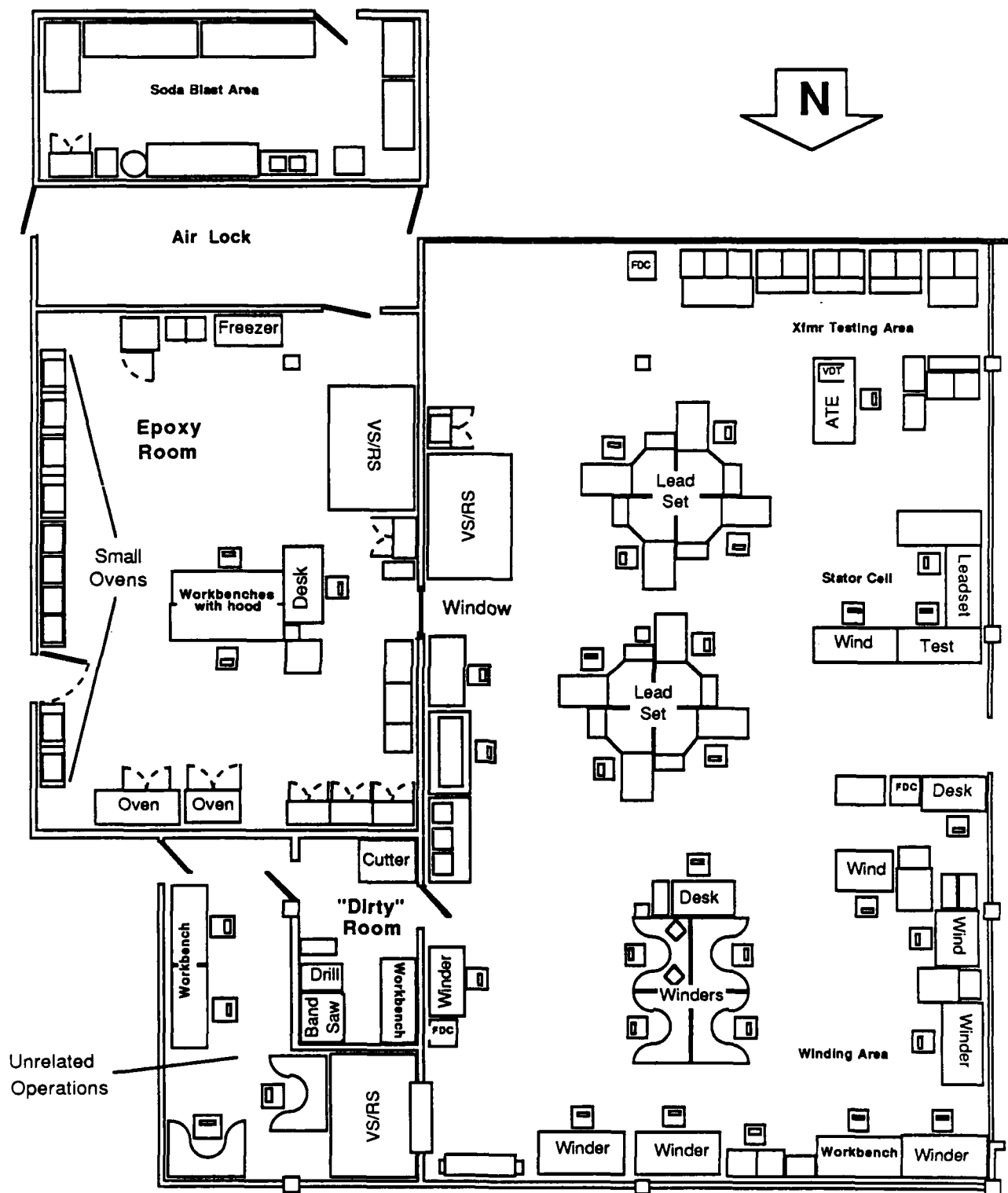


Figure 8.2.2-2 "To-Be" Transformer Area Layout



- 2) Layout is configured with more than adequate aisle space so that variations in process requirements from assembly to assembly do not pose significant flow problems.
- 3) Winding area is laid out so that machinery with high utilization is grouped in a centrally located "island".
- 4) One VS/RS unit is positioned in close proximity to the winding area to provide wire and coil-form supplies to the winding cell (this unit could optionally be configured to be restocked from the back, if desired)
- 5) The second VS/RS is located near the leadset operations to provide supplies support and work-in-process storage.
- 6) A third VS/RS is located in the Epoxy Room for supplies storage.
- 7) The epoxy room is shown as being located outside the current "airlock". Parts are moved to and from this area through a slide up window. (Alternately, if the airlock/clean room environment is not required, an access doorway could be provided at this location).
- 8) A small room is provided for "dirty" operations in the transformer area. Additionally, this room can function as an "airlock" for the transformer area as an alternative to the existing access ways.
- 9) Existing soda blast room has been re-oriented to allow an improved layout and placement of the epoxy area.
- 10) Epoxy room has been re-oriented to provide additional aisle space with a centralized bench area. Curing ovens are grouped along the walls toward one end of the room and clustered around the bench "island" so that work can be prep'd and moved back and forth between ovens and work surfaces.
- 11) Provisions have been made to accommodate all existing transformer test equipment as well as an ATE unit.

The major factors emphasized in the proposed floor plan include more consolidated operations, work place arrangements that promote greater operator interface, and work and materials storage is provided in close proximity to their point of use.

The proposed floor plan provides for an average reduction of flow distance by 95% (see Section 8.4 for a more detailed description as to how this percentage was developed). While this reduction is not necessarily a significant cost driver for evaluating the improved transformer area arrangement, the non-quantifiable improvements in efficiency and the

reduction of material movement required by Group Leaders and stores personnel support this improved layout.

### **8.3 "To-Be" Production/Process Flow**

The "To-Be" production/process flow is presented in the following sections. One of the major improvements in the optimized design of the production/process flow for each of the areas is the development of a straightforward production flow that is aligned with the process flow. Additionally, in the transformer area, the consolidation of the geographically distinct operations will result in significant production flow improvements.

#### **8.3.1 Chassis Area Production/Process Flow**

The chassis area in the "To-Be" configuration integrates the sequential processes necessary to produce a finished chassis for the various military programs so that duplication of stations is unnecessary to ensure uninterrupted product flow.

Each wire wrap plate passes through a series of stations to and from wire wrap depending on the necessary preparation or post wrap work. Since no program volume is sufficient to fully utilize a given station (except wire wrap), the process orientation allows significant labor consolidation. Similarly, in chassis build-up, tooling and parts are centralized and material stocking can be concentrated in storage systems (e.g., VS/RS) to save transit, search, and picking times.

#### **8.3.2 Transformer Area Production/Process Flow**

A survey of the top eighty percent of transformer assemblies and sub-assemblies produced during 1986 was performed to establish the transport profile for the area and determine the resources required to move these parts through the production process.

An external movement analysis revealed that transport between the respective operational areas consumed an estimated 1474 hours during 1986. This is important in two respects. The consolidation of the separate areas could potentially reduce the stockroom allocation to FM & TS. Also, delays in processing and the effective application of FM & TS transformer personnel will be positively impacted as a result of maintaining uninterrupted production flow.

Intra-area movement provides minimal savings. This is a result of the relatively small number of transformer/sub-assembly lots processed. The comparison of flow distances within the "As-Is" and "To-Be" layouts resulted in a five percent transport reduction.

Additionally, the project team believes, and current industry experience bears out, that the combination of consolidating the respective transformer

operations and developing ergonomic work cells will result in productivity gains in excess of ten percent per year.

#### **8.4 "To-Be" Material Flow**

The improvements in the "To-Be" material flow are presented in the following paragraphs. In general, a number of characteristics can be stated regarding the improvements in both the chassis and transformer areas. The most important improvements in the material handling for both of the areas involves the methods and equipment used for material and fixturing storage.

##### **8.4.1 "To-Be" Chassis Area Material Flow**

The chassis area material flow will be significantly improved through the implementation of three major types of material handling and storage devices. These are:

- Vertical Storage and Retrieval Systems (VS/RS)
- Bench-top Rotary Parts Presentation Bins
- Dedicated Material Handling Carts

These three pieces of equipment are described in detail in the following subsections.

##### **8.4.1.1 Vertical Storage and Retrieval Systems (VS/RS)**

In the current chassis area configuration, over 1,000 cubic feet is devoted to storage of all types, including fixtures, wire wrap plates, queued material, work-in-process, fasteners, wire, repair parts, etc. In gross numbers, over a third of material currently stored is related to work-in-process, another third is made up of DITMCO fixtures, cables, and other related miscellaneous materials, and the balance is divided between wire wrap materials and supplies.

In the "To-Be" chassis area operations, a majority of all of the material in these work areas will be stored in Vertical Storage and Retrieval Systems (VS/RS). VS/RS units are automated, micro-processor based storage and retrieval systems which occupy small footprints of space. Items are stored in pans which travel following a vertical enclosed loop track. Pans are brought to work counter height via the shortest route. An operator does not have to bend, search, or grow fatigued looking for an item, therefore improving productivity.

These systems will reduce the floor space utilized for storage significantly and consolidate material into specific areas adjacent to the materials' points of use which reduces the material movement travel time. It will also assist group leaders and operators by significantly reducing the time associated with locating materials.

Figure 8.4.1.1-1 presents the reduction in storage volumes that can be achieved with the use of two Vertical Storage and Retrieval Systems. It is proposed that one VS/RS be oriented near the DITMCO tester to supply production parts and store work-in-process. The second VS/RS will be utilized for wire wrap related parts, fixtures, and supplies. Storage of DITMCO cables will be in cabinets until a feasible set-up arrangement can be developed for their storage by some other means.

Another significant improvement associated with the implementation of the VS/RS units is the purchase of a computer-driven material locating system for each of the VS/RS units. While many users require a simple "go to pan" operation, to take full advantage of these units, a storage and retrieval locating system is proposed. This will serve to eliminate excessive time required to search for the appropriate materials and more optimized utilization of the storage devices.

Figure 8.4.1.1-2 presents an elementary software diagram for a basic storage management system. This type of system consists of five major modules, which are described in the following paragraphs.

#### *Storage Management Module*

The Storage Management Module (SMM) should manage the Storage Database, Part Number Database, and Storage Arrangement Table. The SMM should create inventory records and provide keyed access to the Storage Database, Part Number Database, and the Storage Arrangement Table. The Storage Database should contain the following elements:

- Location (shelf number)
- Part Number (multiple part numbers may be stored on same shelf)

The Part Number Database should contain:

- Part number (either for a specific assembly or sub-assembly, fixturing, cables, wire wrap plates, etc.)
- Location (for known stored parts or fixtures)
- Part number size attributes (for entered part numbers)

The Storage Arrangement Table should contain:

- Location
- Size attributes

#### *System Interface Module*

The System Interface Module (SIM) should be the operator interface module that services the PC keyboard and display. SIM should manage

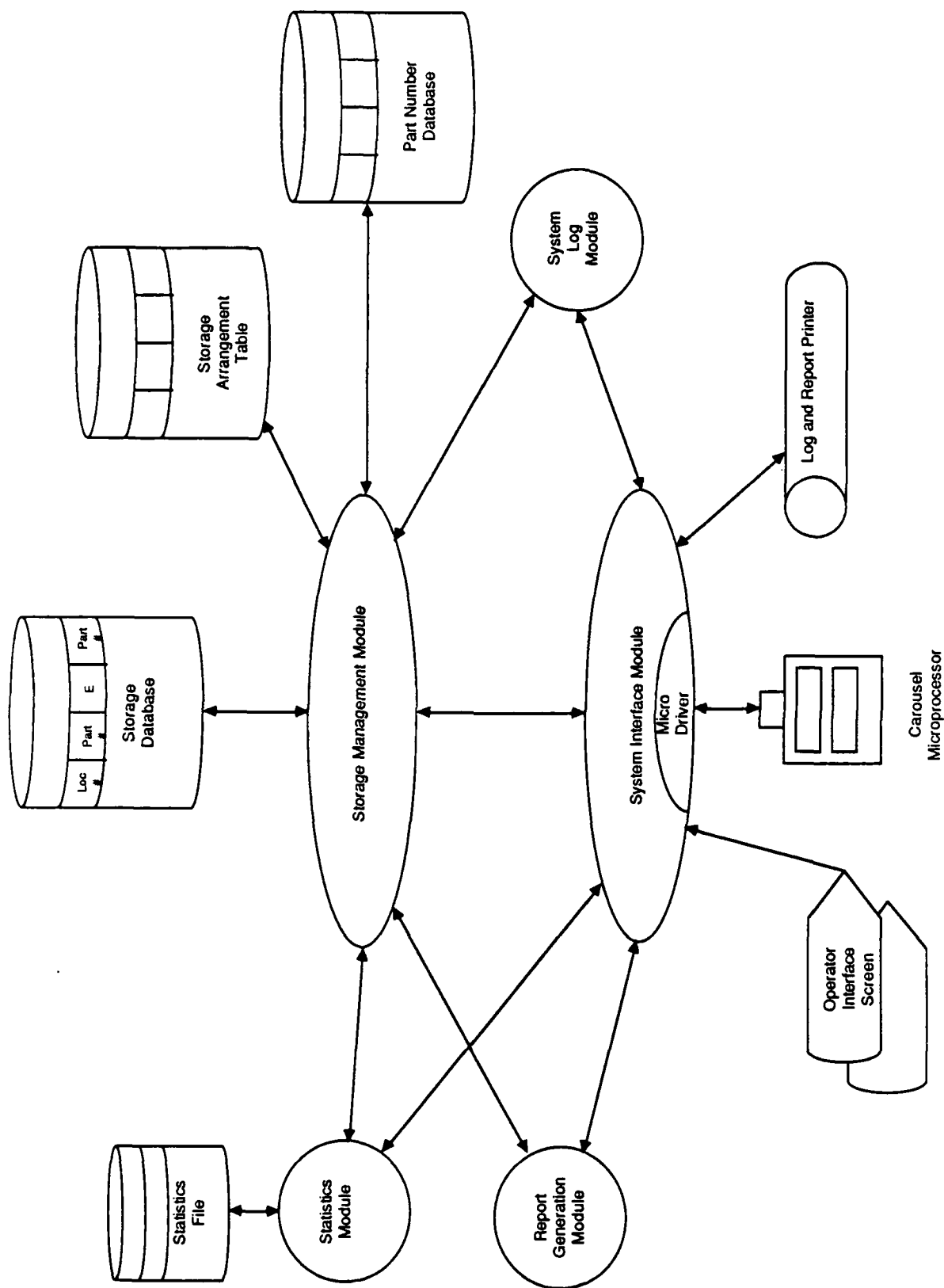
# CHASSIS AREA STORAGE VOLUMES

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
PRESENT METHOD (cu. ft.)	1019	1223	1223	1455	1455	1455	1455	1455	1455	1455	1455
PROPOSED METHOD (cu. ft.)	1019	800	800	800	800	800	800	800	800	800	800
VOLUME REDUCTION (cu. ft.)	0	423	423	655	655	655	655	655	655	655	655

NOTES: 1) USE OF VS/RS TO PROVIDE DYNAMIC STORAGE AS OPPOSED TO STATIC, FIXED-SPACE ALLOCATION.

2) USE OF VS/RS TO STORE FIXTURES, MATERIALS, AND WORK-IN-PROCESS.

Figure 8.4.1.1-1 Chassis Area Storage Volumes



**Figure 8.4.1.1-2 Storage Management System Elementary Software Diagram**

operator inquiry functions, file utilities, report generation selection, and access to system utilities. SIM should produce the following on-line query screens:

- Part number in location
- Size attributes of part number
- Size attributes of location
- Statistics summary

#### *System Log Module*

The System Log Module (SLM) should maintain a disk file that records critical system activity and error conditions for later processing by the SIM report generation routines. All SLM entries should be time-stamped and identified by the originating module. Events logged by SLM should include:

- Put away errors
- Part number location errors
- Operating system error codes returned to programs
- Disk faults

#### *Statistics Module*

The statistics module should keep track of performance information of the put away system.

#### *Report Generation Module*

The Report Generation Module should be a collection of small report generating programs that produce management summary reports.

The implementation of this system as well as the implementation of the Factory Data Collection System and the HMS/BOS system should greatly improve the tracking of material and work-in-process in the chassis area.

#### **8.4.1.2 Bench-top Rotary Parts Presentation Bins**

An aspect of the chassis operations reviewed by the Tech Mod project team that contributes to material handling expense is the numerous small parts utilized in chassis assemblies and sub-assemblies. These parts are stored in bin trays located to one side of the chassis area.

As jobs are set up at a bench location, parts (in the trays) are transported to the designated location by a group leader or the operator. Under the revised layout, these parts would be located at a specific workstation and the access and presentation would be part of a rotary parts storage system consisting of many segmented bins.

These bins are motor-driven and allow an operator to advance a selected part into view by depressing a remote footswitch or control panel button. One of these bins provides spaces for as many as 120 different small parts such as screws, nuts, resistors, capacitors, connector pins, etc.

By grouping parts unique to various assemblies on different levels, increased efficiencies can be achieved through the elimination of searching for material in remote parts bins. Replenishment is similarly augmented.

This equipment could be customized in the future by the addition of position sensing equipment and a locator control scheme which would allow automatic sequencing of parts bins. This set-up should be considered when a tie-in with a workcenter controller is developed.

#### **8.4.1.3 Dedicated Material Handling Carts**

In the proposed plan, material would be transported throughout the work area on carts with a very limited number of shelves and closeable/lockable doors. The major premise behind this is to only have material on the shop floor that is being worked on and all other materials stored. Since work-in-process storage could potentially occupy approximately 200 cubic feet in the Vertical Storage and Retrieval System, improved material handling disciplines must be established.

The benefit of limiting work-in-process storage to carts (with work-in-process in the VS/RS stored due to lack of materials to complete the job or as completed sub-assemblies) is that what is actually "in-process" will be readily apparent. The Japanese liken this method to that of draining a pond to make the bottom a smooth surface. As water is taken away, the largest rocks appear first. As each rock (or unnecessarily stored item) is removed, the pond is further drained until all of the rocks are removed.

By not providing unlimited storage areas, problems related to timely delivery of kitted parts, etc. will surface and be more effectively dealt with.

#### **8.4.2 "To-Be" Transformer Area Material Flow**

The transformer area material flow will be significantly improved through the implementation of Vertical Storage and Retrieval Systems. Currently, the storage of all materials in the transformer area is in a variety of cabinets distributed throughout operational areas. The greatest amount of cabinet space is assigned to store wire and other winding related materials. In other areas, there are seventeen large cabinets and over twenty "under bench top" shelves used to store assembly, leadsetting, and epoxy materials. In total, there are forty-eight individual storage locations totaling over 940 cubic feet.



By establishing three VS/RS units, one each in winding, leadset, and epoxy, this storage space can be centralized for material presently spread around the areas. Furthermore, easier storage and retrieval will be made possible via the automatic locator system described in the previous "To-Be" Chassis Area Material Flow section.

The VS/RS units will increase floor space utilization by concentrating a greater amount of cubic storage in one area through the use of three additional feet in height. By bringing material to a usable height for placement/retrieval, spaces which are normally wasted in cabinets (near the floor or above an operator's head) are reclaimed for use. A ten foot high VS/RS can make available 350 cubic feet of storage in a space that tall cabinets can only provide 190 cubic feet, an increase of 84%. Additionally, travel distance with a VS/RS is cut to one-quarter to access the equivalent volume.

The proposed integrated and consolidated transformer area will contain three VS/RS units. These will serve the main activity areas of wind, leadset, and epoxy. This will provide supplies closely coupled to the point of use. Also, since winding takes up all of one VS/RS unit, the proximity of the second unit will permit any excess storage to be placed in the leadset VS/RS.

As in the case of the chassis area VS/RS (described in Section 8.4.1.1), this equipment is capable of integration into the overall information management system.

## **8.5 "To-Be" Information Flow**

The most significant improvements in the chassis and transformer area information flow will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. While on a conceptual level this system performs all of the same processes as the GAPOS system, the increase in functionality is significant. Because the two systems are similar in the types of functions they will be performing and the final definition of the system has yet to be implemented, the focus of this section will be primarily on the introduction of the Factory Data Collection system and the improvements outlined in this report that can be even further upgraded due to their selection for interfacing with a work center controller.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part being built. It is envisioned that in the future, the FDC system will be expanded to provide location tracking of work-in-process as well.

It is envisioned that at some point in the future the Vertical Storage and Retrieval Locator System will be interface to HMS/BOS, either directly (which is

not recommended) or through another system such as the Factory Data Collection System. This would provide a more integrated material tracking system.

One other program which is currently under evaluation for Honeywell's MAVD is the introduction of a "factoryvision" system (ITM Project 32) which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with a work center controller would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

## **8.6 "To-Be" Equipment**

The following subsections describe the equipment proposed for implementation in the FM & TS chassis and transformer areas. This equipment significantly improves the operations in these areas and provides for the operations of these areas on a higher level of automation with, in some cases, the upward compatibility to an advanced work center controller being considered for future implementation.

### **8.6.1 Chassis Area Equipment Improvements/Upgrades**

There are a number of equipment improvements or upgrades that are presented in the "To-Be" operations in the chassis area that affect the overall work area design. This equipment includes:

- Vertical Storage and Retrieval Units
- Rotary Parts Presentation Equipment
- Material Handling Carts

### **8.6.2 Transformer Area Equipment Improvements/Upgrades**

There are a number of equipment improvements or upgrades that are presented in the "To-Be" operations in the transformer area that affect the work area design. These improvements include:

- Modular, ergonomic workstations
- Vertical Storage and Retrieval Units

### **8.6.3 Transformer Ergonomic Modular Workstations**

Considerable interest has been generated in the electronic manufacturing community over the past few years over improving productivity in the workplace. The FM & TS organization has been evaluating and incorporating some newer, modular workstations into its operations to improve productivity through better arrangement and efficiency at the work surface.

The Tech Mod project team has reviewed several styles of workstations in an effort to determine the most suitable configuration and arrangement which will enhance productivity. The team was assisted in this effort by the findings of the U. S. Navy Electronics Manufacturing Productivity Facility (EMPF) in their study of several types of workstations.

The EMPF, in a study that included both male and female subjects involved in electronic assembly activities, concluded that the most productive environment for workers occurs when the operator is placed in a modular work space with minimal opportunity for visual distraction. The study found that the elimination of "eye contact" in the work environment contributed 22% to the overall productivity of subjects involved in electronic assembly activities, thus allowing concentration on assigned tasks.

The Tech Mod team also reviewed various workstation configurations which could potentially take advantage of the EMPF study results. Two main arrangements were derived that allowed both efficient work flow and economical arrangement:

- Work Cells
- Bench Clusters

The work cell may consist of two or three benches arranged to provide a "U" shaped flow as products are passed through a series of steps in the cell. This arrangement generally conserves floor space and shortens external flow lines. In one version of the chassis area floor plan, this configuration resulted in a flow reduction of over fifty percent when compared to the "As-Is" condition.

The second configuration is a four bench "cluster," which while requiring external circulation to move work from station to station, benefits from requiring a singular utility drop thereby allowing economical installation and relocation. This arrangement allows what FM & TS Production management feels are beneficial operator groupings to accomplish similar or sequence related tasks. Utilizing this type of workstation grouping resulted in a reduction of thirty-four percent in flow distances for the chassis area and is contained in the floor plan exhibits presented earlier for both that area and the transformer area.

The Tech Mod team also reviewed bench styles and construction details from several manufacturers. While most bench manufacturers employ components formed from cold-rolled steel tubing, some utilize aluminum alloy materials which are more than durable enough for the types of activities and weights encountered in electronic assembly, and which offer attractive cost savings in implementation.

## SECTION 9

### SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

The following sections present the detailed specifications that were developed as a result of the analysis and design performed for two areas within Honeywell's FM & TS operations under ITM Project 88. The first section provides system and equipment specifications for the Chassis area and the second section provides system and equipment specifications for the Transformer area.

#### 9.1 Chassis Area Specifications

The chassis area specifications have been developed for material handling and automated storage and retrieval equipment, including:

- Vertical Storage and Retrieval Units
- Computerized Putaway System
- Bench Top Parts Presentation Bins
- Secure Material Handling Carts

The specifications for this equipment are presented in the following paragraphs.

#### Vertical Storage and Retrieval System (VS/RS)

Dimensions:	7' wide x 10' long x 125" high
Counter:	40" high, static controlled
Shelves:	12 (min.)
Pan Pitch:	12"
Pan Depth:	18"
Pan Load Capacity:	500 lbs.
Machine Capacity:	10,000 lbs.
Interface:	RS232C
Controls:	Supervisor's panel with keylock switch, rotary control and position display
Electrical:	230 VAC, 30 amp, single phase

## Computerized Putaway System Specification

The following specification is provided primarily as a preliminary specification and may be modified to meet the specific needs of each individual VS/RS.

Hardware:            Personal Computer with internal hard disk  
                      System Printer  
                      System RS232C Interface Cable  
                      Optional bar code reader

The system hardware interconnections should also allow for networking of PC's. This will allow for networking diskless PC's for complete carousel storage network.

Software:           The system software elementary diagram is pictorially described in Figure 9.1-1. Descriptions of each of the databases and modules are provided below.

### 1)        Storage Management Module

The Storage Management Module (SMM) should manage the Storage Database, Part Number Database, and Storage Arrangement Table. The SMM should create inventory records and provide keyed access to the Storage Database, Part Number Database, and the Storage Arrangement Table.

The Storage Database should contain the following elements:

Location (shelf number)  
Part Number (multiple part numbers may be stored on same shelf)

The Part Number Database should contain:

Part number (either for a specific assembly or sub-assembly, fixturing, cables, wire wrap plates, etc.)  
Location (for known stored parts or fixtures)  
Part number size attributes (for entered part numbers)

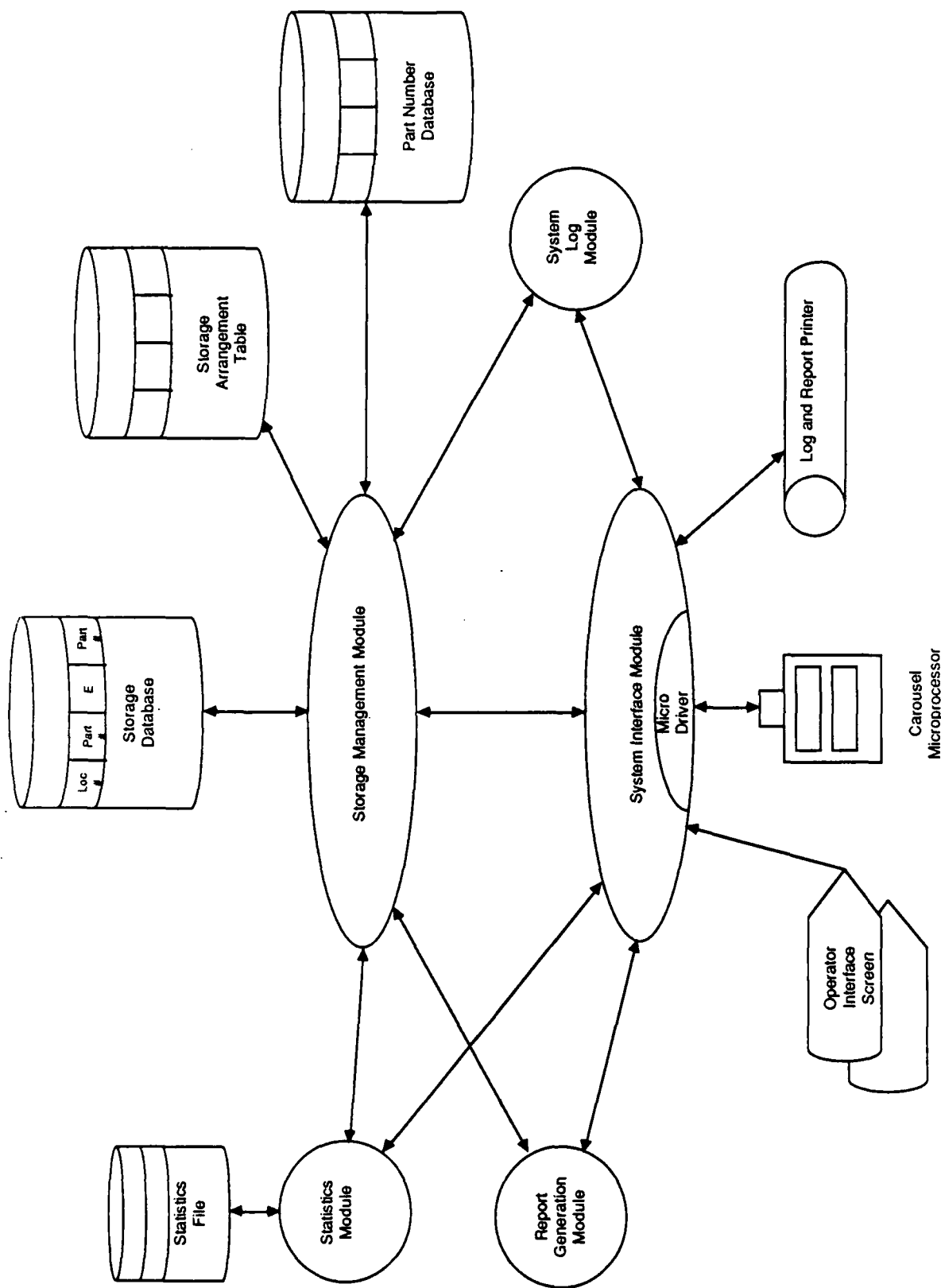
The Storage Arrangement Table should contain:

Location  
Size attributes

### 2)        System interface Module

The System Interface Module (SIM) should be the operator interface module that services the PC keyboard and display. SIM should manage operator inquiry functions, file utilities, report generation selection, and access to system utilities. SIM should produce the following on-line query screens:

Part number in location  
Size attributes of part number  
Size attributes of location  
Statistics summary



**Figure 9.1-1 Storage Management System  
Elementary Software Diagram**

3) System Log Module

SLM should maintain a disk file that records critical system activity and error conditions for later processing by the SIM report generation routines. All SLM entries should be time-stamped and identified by the originating module. Events logged by SLM should include:

Putaway errors  
Part number location errors  
Operating system error codes returned to programs  
Disk faults

4) Statistics Module

The statistics module should keep track of performance information of the putaway system.

5) Report Generation Module

This module should be a collection of small report generating programs that produce management summary reports.

**Bench Top Parts Presentation Bins  
(Rotary Component Dispensers)**

Dimensions: 20.5" high x 24" wide x 17.5" deep  
Trays: 6  
Bins: 20 per tray  
Cycle Time: 1 second (approx.)  
Control: Panel or remote footswitch  
Power: 115VAC, 60Hz

**Material Handling Carts**

Dimensions: 36" long x 24" wide x 30" high  
Shelves: 2 shelves with retainer lip, ESD mats, drag chain  
Capacity: 100 lbs.  
Casters: 3" - 4", rubber, brakes

## 9.2 Transformer Area Specifications

The transformer area specifications have been developed for the ITM Project 88 "To-Be" operations within FM & TS. These include:

- Vertical Storage and Retrieval Units
- Computerized Putaway System
- Ergonomic, Modular Work Benches

The specifications for this equipment are presented in the following paragraphs.

### Vertical Storage and Retrieval System (VS/RS)

See Section 9.1 for a complete description of this item.

### Computerized Putaway System Specification

See Section 9.1 for a complete description of this item.

### Modular Work Benches

Dimensions:	72" long x 36" wide x 30" high. (Optionally, height may be variable but this requirement limits number of vendors).
Work Surface:	ESD controlled with grounding attachments.
Shelf space:	Adjustable footrest shelf. (This may negate the requirement for a variable height work surface).  Metal Instrument Shelf with back panel for mounting color coded cups for fastening hardware. 15" deep x 72" long x 24" high.  Load balancing bar mounted minimum 36" above worksurface.
Drawer space:	Four drawered unit with master-keyed lock that locks all drawers.
Electrical Requirements:	Duplex outlets (110 AC) with raceway (either mounted along work surface or shelf).
Pneumatic Requirements:	Minimum 3/4" air line with two outlets and standard quick-disconnect couplings.
Lighting:	Dual fluorescent tubes in overhead canopy with diffuser.



## **SECTION 10**

### **TOOLING**

As a result of the nature of the design and development efforts (improved material handling), there is no unique tooling required for ITM Project 88.

## **SECTION 11**

### **VENDOR/INDUSTRY ANALYSIS/FINDINGS**

The project objectives which dictated realistic cost-payback relationships ultimately caused the review of a condensed group of material handling equipment vendors. Some equipment had been previously reviewed by FM & TS personnel so that the preliminary search and selection process was bypassed in the interest of eliminating duplication of effort.

Since the ITM Project 88 review of the chassis and transformer areas centered on material handling improvements and equipment upgrades, the selection process focused on the following areas:

- Vertical Storage and Retrieval Systems
- Bench Top Rotary Presentation Bins
- Dedicated Material Handling Carts
- Transformer Area Workstations

#### **Vertical Storage and Retrieval Systems**

Several established vendors were contacted and reviewed for equipment suitability. Principal among these were White, J. Webb, and Kardex. The FM & TS organization has had previous experience with the VS/RS equipment manufactured by Kardex, and has found the capacity and service level satisfactory.

A primary requirement in the transformer area was the physical capacity to support dozens of reels of wire used in winding magnetics. Both Kardex and White had units with capabilities in this area.

The chassis area requires deeper pans to hold tooling plates and various fixtures necessitating a VS/RS unit similar to those specifications exhibited by the White equipment.

All manufacturers were surveyed for the ability to provide standardized software systems to automate parts picking and putaway as well as storage space optimization. The desire to avoid "customized" control software was communicated to vendors quoting on FM & TS requirements primarily to avoid continued maintenance of a non-standard package.

The need for a more optimized storage system in the transformer area was identified very early in the Phase 1 activity of the ITM program. Therefore, Production Engineering began an immediate search for a possible vendor. The equipment which was determined to be best suited for the application was the Kardex Industrier 6000. Two units intended specifically for use in the transformer area were ordered in January, 1986. However, because of space limitations and management decisions delaying the consolidation of the three

transformer areas these units have not been installed. Since Vendor pricing was reasonably competitive for this type of equipment, in the interest of inter-department uniformity, it is intended that Kardex units will be purchased for the chassis area and that the computerized putaway system also be purchased from the same vendor.

### **Bench Top Rotary Presentation Bins**

While several workstation suppliers such as Advance, Kinetech, Isle Industries, etc. have some form of rotary parts presentation, few firms offer a system with the capability of placing dozens of parts within convenient reach of an operator seated at a workbench. Since a multitude of small parts are used in FM & TS (especially in the chassis area), a system was needed which would provide this function. Ideally, a miniaturized VS/RS would be the perfect solution for small parts presentation, but a device capable of handling hundreds of small parts in this manner is not presently available.

A powered rotary parts unit is available from Assembly and Production Aids which exhibits the desired features, but is only capable of holding 120 different small parts. This basically permits about 360 small parts to be within easy reach of an operator if three units are used. This will generally satisfy requirements at any given workstation within the chassis or transformer area.

### **Dedicated Material Handling Carts**

Of all equipment specified for the chassis area, carts are possibly the most generic. Numerous vendors provide a suitable mobile unit. Capacities appropriate to the task of moving work around the chassis area are manufactured by such companies as Metropolitan Wire Goods, Hodges, Gamco Industries, and several others.

Specifications generally cover wheel types, construction, and maximum capacities expected. A review of work flowing through the chassis area indicates that the maximum weight of transported parts, assemblies, or kits falls in the range of 50 to 75 pounds, thus allowing carts of a wide range of structural types to be used.

It is anticipated that FM & TS operations management will review the outlined requirements and match that with a unit generally used in the area at present.

### **Transformer Area Workstations**

Known vendors such as Herman Miller, Straether, Advance, Ergotech, etc. provide a wide range of competitively priced equipment. Some vendors have unique features, which in specialized applications might dictate selection, but the stations proposed for Project 88 are readily available in a configuration meeting the current area specifications. Since a few workstations have been

purchased within the past year (not as a part of this project) from Herman Miller to be used within FM&TS, it was decided to specify Herman Miller equipment for continuity of style unless a strong case can be made for a special application prior to implementation. As a result, the average cost of the previously purchased stations was used for computation of factory costs.

## **SECTION 12**

### **EQUIPMENT/MACHINERY ALTERNATIVES**

Most of the equipment alternatives in ITM Project 88 are vendor-dependent rather than actual alternative technologies. The following paragraphs describe the alternatives to the equipments selected for ITM Project 88 in the event that the primary choice becomes unavailable.

#### **Vertical Storage and Retrieval Systems**

If the specified Kardex VS/RS units become unavailable several suitable alternatives exist. The primary alternative is a Model TB-1261 from White Storage & Retrieval Systems. The cost of the alternative hardware is comparable to the Kardex units, however the software is somewhat higher priced (approximately \$15,000 more).

#### **Bench Top Rotary Presentation Bins**

An alternative to the proposed Rotary Bins would be fixed bins on racks (similar to the "As-Is" method except the bins would be at each workstation). This would be an improvement over the present method but would be somewhat less efficient than the proposed system.

#### **Dedicated Material Handling Carts**

Of all equipment specified for the chassis area, carts are possibly the most generic. Since the initial choice of vendor will depend upon the preferences of operations management to match units generally used in the area at present and numerous vendors provide a suitable mobile unit, making use of one or more of the alternate vendors would have little or no impact on the project implementation.

#### **Workstations**

The workstation vendor chosen (Herman Miller) is one of many which meet the requirements. There are several vendors whose equipment is comparably priced. Therefore, making use of one or more of the alternate vendors would have little or no impact on the project implementation.

## **SECTION 13**

### **MIS REQUIREMENTS/IMPROVEMENTS**

The most significant improvements in the chassis and transformer area in respect to the Honeywell MIS department will be achieved with the introduction of the HMS/BOS system currently being modified for use at the St. Louis Park facility. HMS is a modular system comprised of the following modules:

- Master Production Scheduling (MPS)
- Inventory Records Management (IRM)
- Manufacturing Data Control (MDC)
- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- Purchase Material Control (PMC)
- Production Cost Accounting (PCA)

In addition to HMS, Honeywell is also implementing a process layout system which includes the Process Management System (PMS) and the Factory Data Collection (FDC) System.

The Factory Data Collection (FDC) system has been developed as a means of automatically recording hours an employee expends on a specific operation/part number. This provides important information to FM & TS management both for accounting purposes as well as monitoring the percentage of completion of a specific part being built. It is envisioned that in the future, the FDC system will be expanded to provide input to a system for location tracking of work-in-process as well.

Honeywell is also developing the specifications for a Work Center Manager System (WCM). While these specifications are still in the development phase, the improvements described in this document take into account the eventual implementation of these efforts and have been designed for future interface to a Work Center Manager System. The following paragraphs describe the basic functionality required of the Work Center Manager System.

A Work Center Manager System is typically a major piece of a hierarchically structured computerized factory control system. Residing at a higher hierarchical level than the WCM are the corporate systems and the MRP and MRP II systems such as HMS/BOS. Because MRP II systems are batch processing operations, the Work Center Manager has been assigned the responsibilities of direct, real time control of the factory floor. In this role, the system is responsible for short term, global scheduling tasks (during the operating day) and coordinating the inter-cell operations (such as material handling "hand-offs") that reside below it in the controls hierarchy.

It is also envisioned that the Work Center Manager will distribute graphics and textual process data to workstations and will maintain a process

data library which will be accessed by various pieces of the process control hierarchy (such as PLC's and other automated equipment).

It is envisioned that at some point in the future the Vertical Storage and Retrieval Putaway or Locator System will be interfaced to HMS/BOS, either directly or through another system such as the Factory Data Collection System to provide a more integrated material tracking system. It is not recommended that the Locator or Putaway System be interfaced directly to HMS/BOS due to the nature of a hierarchically controlled manufacturing operation. Systems such as HMS are typically batch-oriented systems and do not allow for the processing of real-time, lower level activities such as material/location tracking. It is therefore recommended that the Locator or Putaway System be interfaced through the Factory Data Collection System or the Work Center Manager.

One other program which is currently under evaluation for Honeywell's MAVD in conjunction with the Work Center Manager System is the introduction of ITM Project 32, which will present production layouts and other production related information to each of the operators on the shop floor. This type of system, interfaced with the Work Center Manager System would raise Honeywell's operations to the most advanced, state-of-the-art achievable with the computing technology available today.

## **SECTION 14**

### **COST BENEFIT ANALYSIS AND PROCEDURE**

In analyzing ITM Project 88, attention was focused on the methods and processes utilized in the FM & TS chassis and transformer areas. Activities reviewed in the transformer area included winding, leadset, testing, impregnating, and marking. In the chassis area, operations studied included machine operations, mechanical assembly, electrical assembly, wire wrapping, and continuity testing (DITMCO).

In the initial stages of the project, several areas were identified as cost drivers and reviewed for possible savings using the methodology shown in the process diagram of Figure 14.0-1. This also required the identification of productivity and quality factors as a means of evaluating the cost drivers.

#### **14.1 Productivity and Quality Factors**

The productivity and quality factors that exhibited the greatest potential for benefit were:

- Hours Spent Moving Material
- Operator Productivity
- Group Leader Time Expenditures
- Production Controller Time Expenditures

Areas identified from the contract ledger data and foreman's cost control reports which did not result in significant benefit were:

- Scrap
- Rework

Because of the diversity of product and/or the low annual volume levels, both rework and scrap were considered to be at relatively low levels in the ITM Project 88 areas.

The following paragraphs describe the major productivity and quality factors in the transformer and chassis areas for ITM Project 88.

#### **Standard Hours**

Product standard hours were derived from internal Honeywell documentation and extended for 1986 production volumes to establish "As-Is" conditions. These totals were compared to those logged in the Foreman's Cost Control report for 1986 as a validation measure.

Specific operation measurements were performed by Industrial Engineering to form a baseline for "To-Be" operations in group leader and



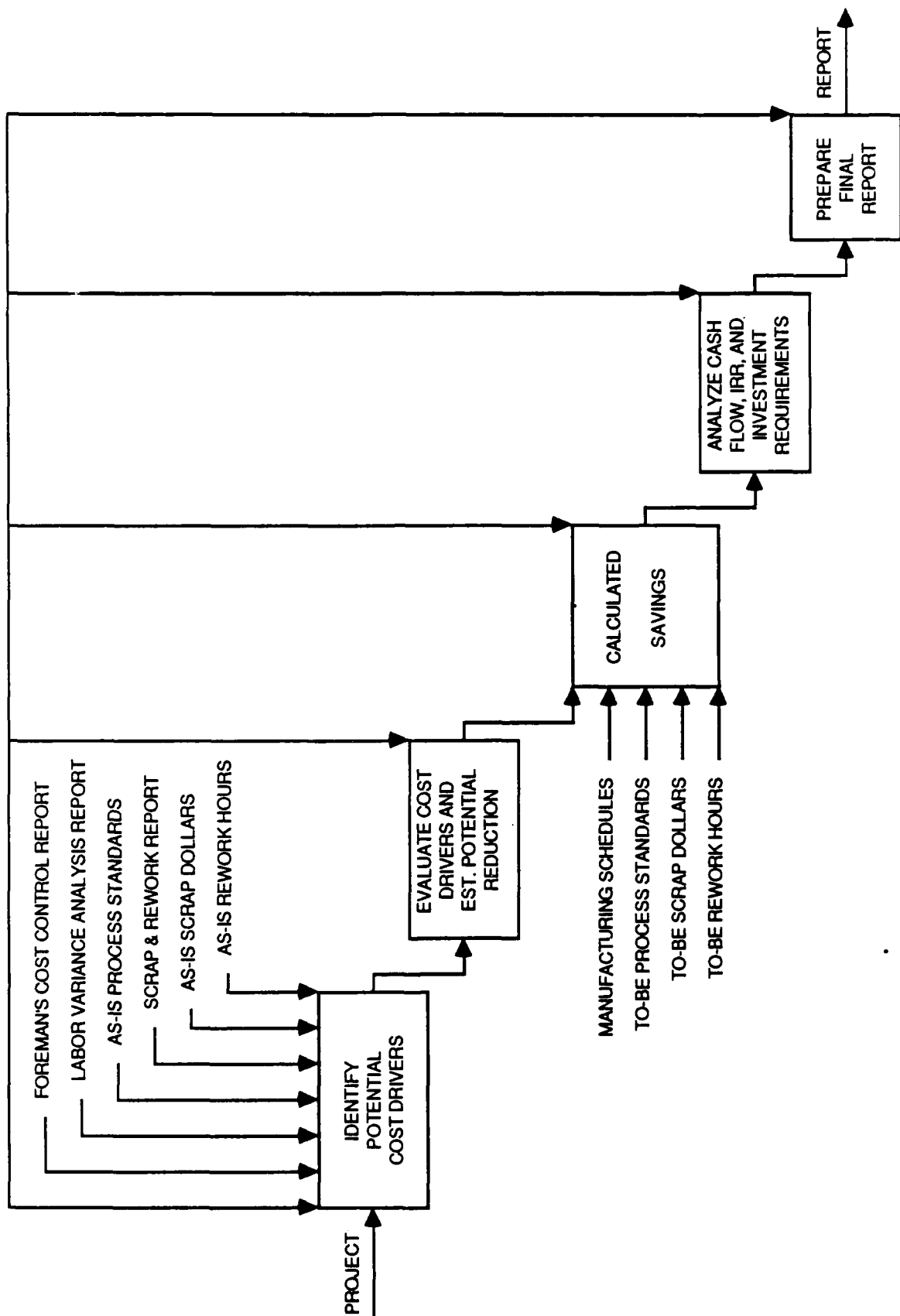


Figure 14.0-1 Cost Benefit Analysis Methodology

production control activities. Estimates of most "To-Be" operational standards were derived from study data gathered by the project team.

Evaluation of savings utilizing modular workstations was supported by data obtained in a study performed by the U.S. Navy Electronic Manufacturing Production Facility (EMPF), China Lake, CA and generally substantiated by productivity increases experienced in the electronics industry.

### **Actual Hours**

In determining savings for the chassis and transformer areas, actual operating ratios derived from Foreman's Cost Control reports were utilized. All standard hours were "normalized" to actual hours to perform "As-Is" versus "To-Be" comparisons on an area-by-area basis. This method is then able to take into account all operational factors not normally included in standards.

### **Assumptions**

All calculations are tabulated for ten yearly periods by quarter, beginning with the implementation point. Generally, implementation commences during 1988.

Production rate increase/decreases are calculated based on the ten year marketing forecast for FM & TS revenue projected from factory production. This approach removes sources of revenue not directly attributable to products manufactured in the FM & TS production facilities addressed in the Tech Mod ITM Project 88.

## **14.2 ITM Project 88 Cost Drivers**

The following paragraphs describe the cost drivers for ITM Project 88.

### **Chassis Transport Direct Labor Savings**

The measured average distance traveled per job within the "As-Is" area is 187 feet. The average "To-Be" distance traveled per job is estimated at 88 feet (47% reduction). Movement was then estimated at 1.5 feet per second.

The percentage escalation in annual hours for the chassis area was derived from 1986 usage data multiplied by the annual estimated growth in FM & TS revenue (1987-1998). Hourly rates, burden, and escalation rates were obtained from Honeywell's Cost Estimating .

### **Transformer Transport Direct Labor Savings**

The measured intra-area transport within the "As-Is" locations is an average of 221 feet. The "To-Be" intra-area distance was measured at an

average of 210 feet. Lot count was derived from 1986 data. Additionally, movement was estimated at 1.5 feet per second.

#### **Transformer Workstations Direct Labor Savings**

"As-Is" total hours were taken from the 1986 production matrix. "To-Be" hours were calculated for bench related work (leadset) only (53 percent) and excluding wind, test, and epoxy operations. The productivity factor from the EMPF study (22 percent) was then multiplied by the leadset percentage.

No percentage escalation in transformer annual hours is included due to a management operational decision for the area dictating an essentially level build schedule. Hourly rates, burden, and escalation rates were obtained from Honeywell's Cost Estimating department .

#### **Transformer Group Leader Labor Savings**

Group Leader savings were based on one group leader expending 24.6 percent of time on material related issues in the "As-Is" condition. The "To-Be" condition anticipates a reduction of group leader material related time to ten percent of total annual hours after installation of the material handling and tracking system. It is also assumed that there will be no increase in group leader headcount over the span of the project.

#### **Chassis Group Leader Labor Savings**

Group Leader savings were based on one group leader expending 28.2 percent of time on material related issues in the "As-Is" condition. The "To-Be" condition anticipates a reduction of group leader material related time to ten percent of total annual hours after installation of the material handling and tracking system. It is also assumed that there will be no increase in group leader headcount over the span of the project.

Group Leader available time is estimated at 1800 hours/year. The savings assumes implementation in the fourth quarter of 1988. Hourly rates, burden, and escalation rates were obtained from Honeywell's Cost Estimating department .

#### **Production Control Labor Savings**

Production Control savings were based on the equivalent of one production control person expending 25 percent of total time on material related issues in the "As-Is" condition. The "To-Be" condition anticipates a reduction of production control material related time to ten percent of total annual hours after installation of the material handling and tracking system.

It was assumed that there would be no Production Control headcount increase over the duration of the project. Calculations utilized 1800 hours/year

as total available time. Hourly rates, burden, and escalation rates were obtained from Honeywell's Cost Estimating department .

#### **14.3 Capital and Expense**

The capital, recurring and non-recurring expenses for Project 88 are shown in Figure 14.3-1.

#### **14.4 Project Savings and Cash Flows**

The savings to be realized in this project exceeds Honeywell's Military Avionics Division hurdle rate. The Project's cash flows are shown in Figure 14.4-1 with the assumption that capital will be available per the implementation plan.

# PROJECT 88 EXPENDITURE SUMMARY

CAPITAL COSTS			EXPENSE COST		
	GROSS COST	CAPITALIZATION YEAR		GROSS COST	YEAR EXPENSED
CAPITAL COSTS			EXPENSE COST		
MACHINERY COST			NON-RECURRING EXPENSES		
AREA PREP. (HI)	\$117,407	1988	AREA PREPARATION (HI)	\$66,900	1988
VS/RS UNITS	<u>\$106,628</u>	1988			
SUB-TOTAL	\$224,035	1988	SUB-TOTAL	\$66,900	
FURNITURE COST			TRAINING		
MATERIAL CARTS	\$9,852	1988		\$1,300	1988
WORKSTATIONS	<u>\$34,770</u>	1988		<u>\$1,600</u>	1989
SUB-TOTAL	\$44,622	1988	SUB-TOTAL	\$2,900	
COMPUTER COST			PROCESS MODIFICATION		
MAT'L LOCATOR SYS	<u>\$26,657</u>	1988		\$3,900	1988
SUB-TOTAL	\$26,657	1988		<u>\$1,600</u>	1989
			SUB-TOTAL	\$5,500	
	<u>\$295,314</u>	1988	VS/RS PROGRAMMING		
TOTAL CAPITAL COST	\$295,314			\$1,300	1988
				<u>\$800</u>	1989
			SUB-TOTAL	\$2,100	
				\$73,400	1988
				<u>\$4,000</u>	1989
			TOTAL NON-RECURRING COST	\$77,400	
			TOTAL CAPITAL AND NON-RECURRING	\$372,714	
			RECURRING EXPENSES ANNUAL MAINTAINANCE	\$5,100	

Figure 14.3-1 Project 88 Expenditure Schedule

PROJECT 88 CASH FLOW SUMMARY

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL
Capital	\$295,314	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$295,314
Non-Recurring Expense	\$73,400	\$4,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$77,400
Recurring Expenses	\$0	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$5,100	\$51,000
Savings	\$0	\$108,756	\$143,456	\$182,020	\$193,208	\$205,441	\$218,749	\$233,558	\$249,429	\$265,972	\$283,877	\$2,084,466
Depreciation	\$26,929	\$49,376	\$41,311	\$34,859	\$29,697	\$22,902	\$16,932	\$18,821	\$18,821	\$18,821	\$16,845	\$295,314

Figure 14.4-1 Project 88 Cash Flows

## SECTION 15

### IMPLEMENTATION PLAN

The implementation plan for ITM Project 88 initially developed out of an earlier review of factory requirements and the recognition of a need to initiate modernization activities within the FM & TS Production area. ITM Project 88 concentrated attention on improvements which could be made in material handling methods and area relayout within the FM & TS Chassis and Transformer Production areas.

Since the equipment proposed for acquisition is readily available from several vendors, implementation can be accomplished within a relatively short period (under six months) and will be paced by the availability of physical facilities.

#### 15.1 Implementation Plan Activities

Implementation of ITM Project 88 activities is depicted in the Plan Schedule (Figure 15.1-1). Since the equipment can be accommodated within the existing production area, acquisition can commence upon receipt of project approval. The improvements scheduled for ITM Project 88 include the following:

- Relayout and relocation of Chassis and Transformer Areas
- Installation of Vertical Storage and Retrieval Systems
- Implementation of VS/RS Putaway/Locator System
- Installation of Bench Top Presentation Bins
- Purchase and use of Dedicated Material Handling Carts
- Restructuring of group leader and production controller activities

The availability of factory floor space will allow installation of the improved product flows as well as the planned operational parameters for the improved equipment.

ITM Project 88 implementation will take place in three basic phases:

Phase	Activity
I	Program Planning
II	Acquisition, Installation, and Training
III	Operation and Validation

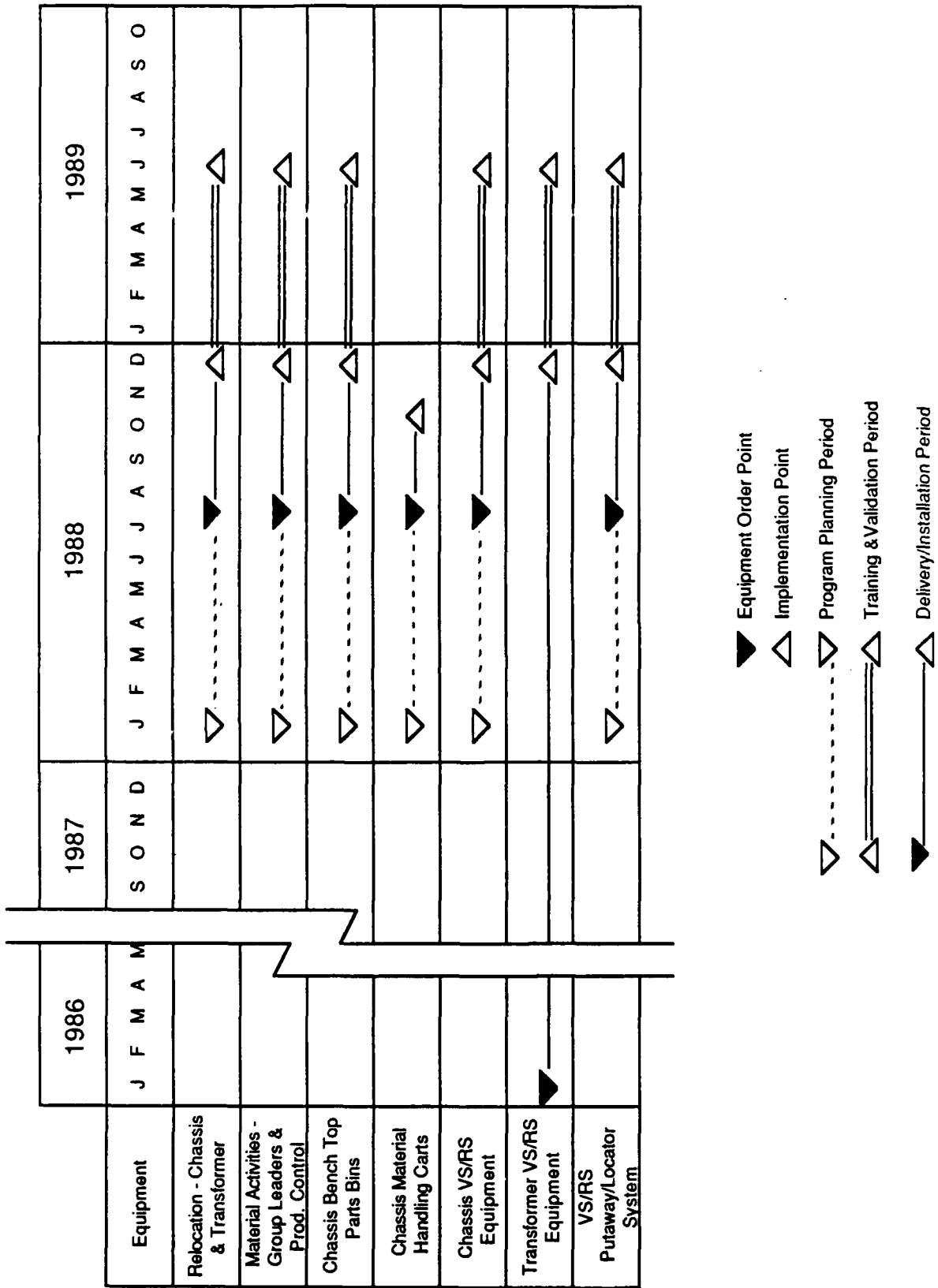


Figure 15.1-1 Project 88 - Implementation Plan



### **15.2 Phase I - Program Planning**

During this phase, all documentation relating to purchasing of the equipment and/or software should be finalized. This will permit immediate initiation of purchase orders upon project approval.

### **15.3 Phase II - Acquisition, Installation, and Training**

Upon placement of orders, physical preparations can commence.

Sufficient time will be available to stabilize equipment locations which fit into revised areas and product flows and make adjustments in processes and methods which will more effectively integrate the new equipment.

Prior to installation at Honeywell, all software systems will be validated at the respective vendors. All parameters which are customized to Honeywell's requirements will be functionally demonstrated before delivery.

### **15.4 Phase III - Implementation and Validation**

Depending on the respective equipment, implementation is projected to occur either in the third or fourth quarter of 1988. It is assumed that all necessary documentation changes associated with the scheduled build of principal models will be completed prior to the start of this phase. This will permit an accurate measurement of the benefits of each improvement and validation of the project savings.

Since the implementation of nearly all the modifications in ITM Project 88 impact direct labor performance, the principal validation in the "To-Be" organization will be derived from the "Foreman's Cost Control" records on a month-by-month basis. Additionally, time studies evaluating selected standards may be conducted to validate projected values. Revised paybacks can then be estimated with the resulting "live" data.

## **SECTION 16**

### **PROBLEMS ENCOUNTERED AND HOW RESOLVED**

- Problem: Availability of space for ATE Central facility to be located with FM & TS area upon project implementation.
- Solution: Chassis area was combined with the relocated transformer facility inside the clean room area.
- Problem: Translating various FSO marketing projections of future revenue into growth figures applicable to FM & TS.
- Solution: Figures were ultimately subjected to a process of review and scrutiny to ascertain those actually applicable to FM & TS Production.
- Problem: Preliminary designs, while technically correct, did not reflect FM & TS preferred operational mode.
- Solution: Subsequent designs were modified in a "working meeting" atmosphere so as to contain a maximum number of features desired by the operational personnel who would be implementing and using them.
- Problem: Large quantities of parts related data presented a significant data reduction task to derive usable summaries.
- Solution: Large data matrices were developed to integrate product description, operation, standards, and quantity data. This enabled accurate and comprehensive summaries to be developed.
- Problem: Multiple locations were potentially available for future operations necessitating significant relay layout efforts.
- Solution: Area elements were entered into CAD database allowing easier update and relay layout as revisions and relocations were proposed.
- Problem: Significant amounts of tabular data developed and continually modified to reflect current rates, times, and quantities. This was potentially a large clerical task.

Solution: Data was linked and manipulated via powerful spreadsheet programs thus minimizing clerical effort.

## **SECTION 17**

### **AREA FOR FUTURE CONCERNS/DEVELOPMENT**

#### **Future Concerns**

- As implementation of Factory Data Collection (FDC) is considered and initiated, attention should be given to providing only those data elements which are necessary for specific area functions to be available in that area. This will reduce the "clutter" of data which could potentially impede the performance of the system. This, essentially, is the essence of hierarchically linking work centers, cells, stations, etc. so that each node has the key resources necessary to accomplish its task.
- Equipment has been proposed for this project in which capabilities exist for future inclusion in local factory networks. This will facilitate future factory modernization. It is important that any automated equipment under consideration be viewed as necessarily including this capability.

#### **Future Development**

- Any replacement equipment should have the capability to interface or network so that data can be exchanged and configuration can be controlled.
- FM & TS should continue to advance the requirement for "design for manufacture" to facilitate future cost reductions.
- Continuous evaluation of equipment coming into the marketplace will uncover price-performance "breakthroughs" that signal a cost effective solution to earlier, uneconomic alternatives.
- Work area arrangements should be sensitive to product volume and models to take advantage of the largest potential savings.
- FM & TS should resist any future considerations for "splitting up" transformer or chassis activities, thus avoiding increased material handling costs.